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PALEOMICROFLORA OF THE LOWER PART OF THE
ASHVILLE FORMATION OF SASKATCHEWAN

by



TERENCE EDWARD PATTERSON

A THESIS

SUBMITTED TO THE FACULTY OF GRADUATE STUDIES
IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE
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DEPARTMENT OF GEOLOGY

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The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies for acceptance, a thesis entitled "Paleomicroflora of the Lower Part of the Ashville Formation of Saskatchewan", submitted by Terence Edward Patterson in partial fulfilment of the requirements for the degree of Master of Science.

ABSTRACT

Sixty species belonging to thirty-eight genera of spores and pollen and seventy-one species of marine dinoflagellates belonging to thirty-five genera are figured and described from the lower part of the Cretaceous Ashville Formation of central and east-central Saskatchewan. The assemblage provides stratigraphic, chronologic and broad paleoecological information.

The microfloral assemblage indicates that the lower Ashville Formation is correlative with part of the Joli Fou and Viking Formations and the upper shale unit of the lower Colorado Group and equivalent strata in western Canada. In the United States the Patapsco Formation of Maryland and part of the Fredericksburg Group of Oklahoma are correlative. In Europe the upper Gault-Cambridge Greensand sequence is partially equivalent. On the basis of the assemblage the lower part of the Ashville Formation in the two drill-holes studied is late Albian in age.

Paleoecological interpretations support prior evidence of a shallow epicontinental sea and indicate the presence of a subtropical to temperate vegetation on the neighboring land.

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Mr. F. Dimitrov reproduced the plates. Mrs. D. Haugan typed the preliminary manuscript and Mrs. H. Meyer typed the final manuscript.

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CHAPTER ONE - INTRODUCTION

It has been the object of this study to determine the spore, pollen and dinoflagellate content of the lower part of the Ashville Formation and from the assemblage to provide information about the age, stratigraphic position of the strata and paleoecological conditions of the area. The lower part of the Ashville Formation is defined here as the strata lying below the base of the Fish Scale Zone and above the Swan River Group in the study area.

Acritarchs and most bisaccate pollen have been excluded from the study because both are long ranging and thus are of little stratigraphic value and also because bisaccate pollen is difficult to speciate.

Previous Pertinent Works on Ashville Strata and other Lower Cretaceous Strata in North America

Early stratigraphic reports and lithologic reports of the Ashville Formation were made by Tyrrell (1892) and Kirk (1929). The Ashville was given little consideration until the late 1940's largely because it was marine shale which had no economic significance. Since that time paleontologists, biostratigraphers and palynologists have become interested in its fossil content.

Important megafaunal and microfaunal studies have been made on equivalent and related strata by McLearn (1937), Wickenden (1945, 1951), Stelck (1950, 1958), Stelck et al. (1956), Mellon and Wall (1956), Guliov (1967), and Warren and Stelck (1969).

Palynological studies were initiated in western Canada by Rouse (1957) with a description of spores from the Upper Cretaceous Oldman Formation of Alberta. Since that time other valuable work has been published. Pocock (1962,1965) described microflora of the Jurassic-Cretaceous boundary of western Canada and also from Lower Cretaceous strata of Saskatchewan. Singh (1964) studied the microfloral content of the Mannville Group of Alberta and his study was followed by a study of microflora from the McMurray Formation by Vagvolgyi (1964). Manum and Cookson (1964) studied a lower Upper Cretaceous assemblage of microplankton from the Arctic Islands of Canada. Norris (1967) continued the work of Singh (1964) upward into the lower part of the Colorado Group in Alberta, while Steeves and Wilkins (1967) illustrated some spores from the Lower Cretaceous of Saskatchewan. Recently Davey (1969) published the first of a two part series on microplankton from lower Colorado strata in Saskatchewan. The study of Davey and that of Steeves and Wilkins provide the only palynology of the Ashville Formation published to date.

A sedimentation and stratigraphic study of the Lower Cretaceous rocks of southeastern Saskatchewan done by Price (1963) also added to the geological knowledge of the study area.

Pertinent Work in the United States

Significant information on Lower Cretaceous microfloral assemblages in the United States include works by Groot and Penny (1960) on Cretaceous sediments of Maryland and Delaware and studies by Groot et al. (1961) on the Raritan, Tuscaloosa and Magothy Formations. These studies were followed by the excellent detailed study of Brenner (1963) on microflora

of the Potomac Group of Maryland and Delaware (1967) and subsequently Tasch et al. (1964) published an assemblage of microplankton from the Albian Kiowa Shale of Kansas. More recently a study of the Fredericksburg Group of Oklahoma has been published by Hedlund and Norris (1968).

Location of Samples

Cored intervals from the lower parts of the Ashville Formation were sampled from two drill-holes. Alwinal Sarcee (Lsd.4, Sec.28, Twp.33, Rge.23, W. 2nd Mer.) is about sixty-five miles southeast of Saskatoon; the other well, Southwest Potash Bredenbury (Lsd.11, Sec.36, Twp.22, Rge.1, W. 2nd Mer.), is about twenty-five miles southeast of Yorkton. The location of the drill-holes is shown on figure 1. Sixty-three samples were studied; their positions are shown on figures 6-9. Lithologic "tops" used have all been determined by Dr. G.D. Williams.

Classifications and Terminology

Morphological classifications have been used for the spores and pollen as well as the microplankton because it is difficult to assign species to higher taxa when dealing with microflora this ancient. For spores and pollen the morphological classification revised by Dettmann (1963) from Potonié and Kremp (1954) is used. Dinoflagellates are classified according to the morphological system of Sarjeant and Downie (1966).

Polospore terminology follows Kremp (1965) and in part Singh (1964) and for the dinoflagellates the terminology is that of Davey et al. (1966) and Evitt (1961b, 1967a).

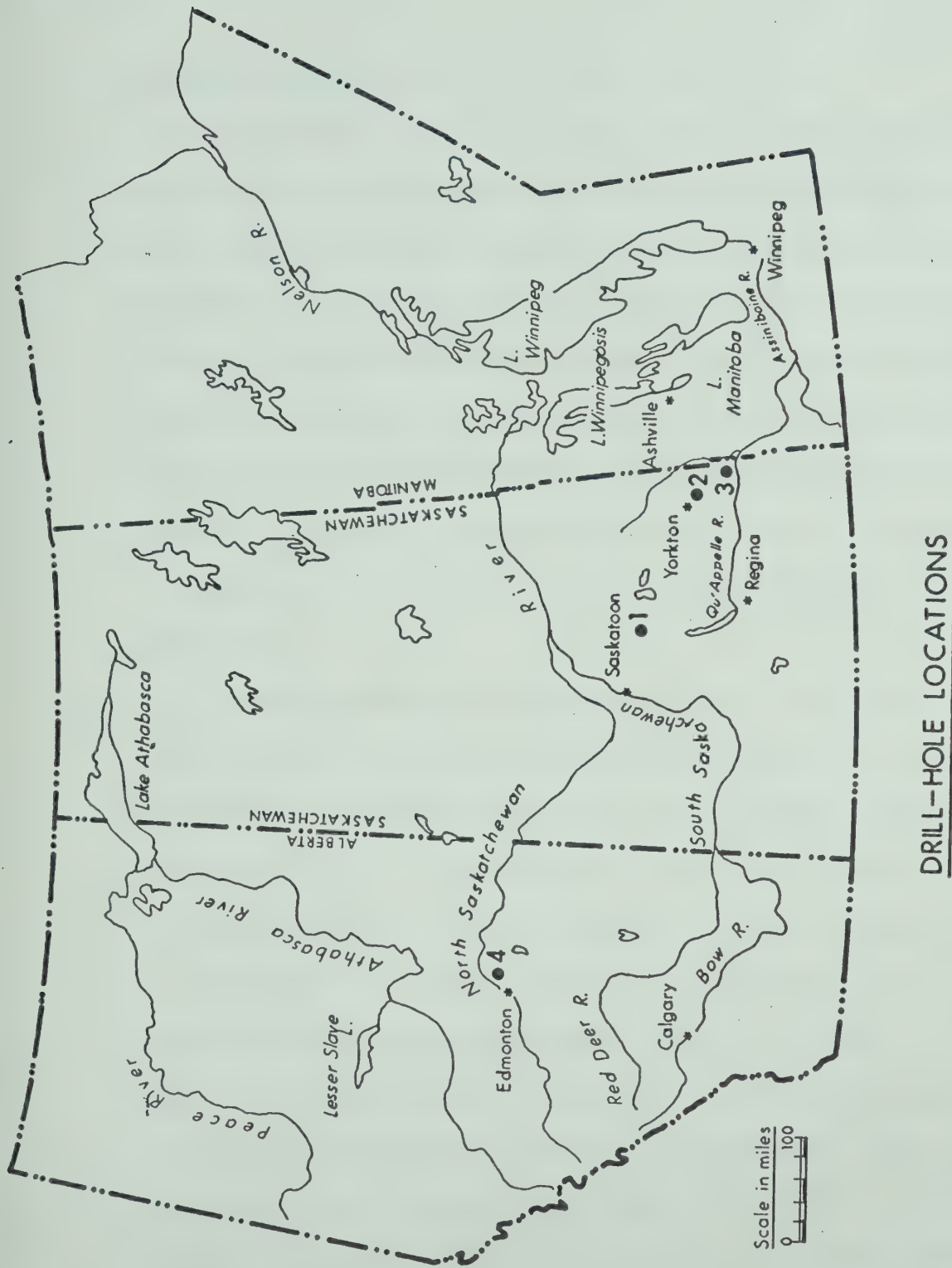


Figure 1. Location map

CHAPTER TWO - STRATIGRAPHY

Position and Location

Stratigraphically the Ashville Formation lies above the Lower Cretaceous Swan River Group and below the calcareous shales of the Upper Cretaceous Favel Formation. The name Ashville is generally applied where the Viking Formation cannot be recognized lithologically, although both the Viking and the Fish Scale Zone can be traced on electric and radioactive logs into southwestern Manitoba where approximately half the Ashville beds lie below the Fish Scale Zone (Rudkin 1964, p. 165). Regional dip of the strata is mostly west or southwest at a rate of 6 to 10 feet a mile (Wickenden 1945, p. 54).

Type Section

The name Ashville was suggested by S.R. Kirk (1929, p. 117B) for beds exposed on Wilson River near the village of Ashville in Township 23, Ranges 20 and 21, West of the Principal Meridian, Manitoba (Wickenden 1945, p. 17). According to Wickenden these beds have proven to be a mappable unit and thus properly represent a formation.

Nowhere is a complete section of Ashville exposed, but along Wilson River the top and bottom are exposed. According to Wickenden (1945, p. 18) the difference in elevation between the top and bottom of the formation is about 154 feet but the outcrops used to determine this difference are about 6 miles apart and there is no evidence to indicate what the attitude of the beds is within this interval.

A comprehensive description of the type section was given by Kirk (1929, p. 117B). "The rock of the Ashville is generally dark grey or almost black shale; carbonaceous and essentially non-calcareous in

composition and capable of being worked into a soft clay. Pyrite is present and secondary growths of well-formed selenite crystals are abundant, together with the yellow powdery incrustation on lamination planes and joint fissures common to all the non-calcareous shales of Manitoba. This material may owe its color to the presence of a small amount of melanterite, this mineral being found also as an efflorescence on the surface of some talus banks of shale. The shale is soft and breaks down readily into thin irregular flakes, so that the cut banks of streams on which it is exposed are almost invariably covered by a loose talus of its fragments. On drying these weathered particles tend to assume a dull silvery color. Some beds are highly fissile and of a chocolate brown color; material of this type being, in most cases, heavily charged with brown fragmentary remains of small fishes."

"Some beds of the Ashville ... contain a considerable proportion of fine sand. Thin beds of bentonitic clay are numerous...."

"Although the Ashville beds are predominantly non-calcareous they include some calcareous concretions as well as bands of impure limestones." "Locally these bands have been found crowded with oysters and the "matrix" of the rock is found to be composed of calcareous prisms, presumably from the shells of an Inoceramus. Fish teeth and scales are also present.... Another feature of interest is the occurrence of a thin, highly phosphatic band among the shales on Wilson River, 1/2 mile southeast from Ashville. It is jet black and entirely made up of fish teeth, vertebrae and other bones of fishes."

Lithology

Other lithologic descriptions have been compiled from drill-hole data as well as outcrop descriptions (Wickenden 1945, Alberta Society of Petroleum Geologists 1960).

According to Wickenden (1945, p. 17), "The Ashville is made up of dark grey to black shales associated in part of the area with some silt and sand beds. Two types of shale are recognized. One, in the upper part of the formation, is a greasy black rock that weathers brown or a pinkish brown and breaks into numerous flakes or flat chips. The lower shale is dark grey and has a more clayey texture. It breaks into chunky fragments. The lower part of the Ashville contains some glauconite with the shale A silt member occurs between the two shales in the northern part of the area."

Lower Contact: Wickenden (1945, p. 17) described the contact with sandy beds of the underlying Lower Cretaceous strata as essentially transitional.

Upper Contact: At the top of the Ashville there is a gradational transition through a few feet of shale to the dominantly calcareous beds of the overlying Keld Member of the Favel Formation (Kirk 1929, p. 118B).

Paleogeography and Depositional Environment

Paleogeography: The Early Cretaceous epoch in western Canada and the central United States was a time of epicontinental seaways. Rocks of western Canada and the western interior of the United States are part of a long, wide belt extending from eastern Mexico into the Arctic region. Accounts of the patterns of the seaways and deposition are given by Cobban and Reeside (1952), Reeside and Cobban (1960), Stelck (1958), Rudkin (1964) and Wulf (1962).

Maximum extent of the Joli Fou-Skull Creek sea is shown in Wulf (1962, p. 1410) and the maximum extent of the Colorado-Mowry sea is shown in Wulf (1962, p. 1412).

Until middle Albian time the Cretaceous seas of western Canada were of boreal origin. It was not until middle Albian time that a Gulf Coast connection can be postulated and this connection is assumed to be the forerunner of widespread inundations during upper Albian time. The Haplophragmoides gigas fauna found in the Joli Fou Formation of upper Albian age represents the transitional onlap microfossil suite (Stelck et al. 1956, p. 19).

Guliov (1967, p. 13) stated that "...the abrupt termination of Early Cretaceous arenaceous sedimentation and the initiation of argillaceous sedimentation in the Plains area of Central Alberta and Saskatchewan has resulted in a sharp boundary between the Mannville and Colorado Groups." On the basis of faunal evidence ".... this represents the swing over from Arctic flooding to Gulf of Mexico flooding in the interior of the continent." (Stelck 1958, p. 6).

According to Stelck (1958, p. 6) the early onlap phases of the Joli Fou sea are expressed by the Swan River Group in Manitoba.

Depositional Environment: The section in eastern Saskatchewan and Manitoba is thin but both stratigraphic and paleontologic evidence indicates that a complete Lower Colorado section is present. This represents a condensed section deposited well out in the marine basin a considerable distance from sedimentary source areas (Rudkin 1964, p. 167). He concluded that as there are no indications of shoreline conditions here, the eastern edge of the early Colorado sea probably lay at least 100 miles east of the present eroded edge of the Lower Cretaceous beds (Rudkin 1964, p. 167).

According to Price (1963, p. 40) during the earliest Cretaceous, sediments from the west maintained the surface of deposition at or near sea-level in the area of the Blairmore Group in western and southern Alberta. Northwest and eastward, marine beds in the Mannville indicate open sea but these beds onlap against an eastward shallowing bottom in central and eastern Saskatchewan. Low salinity, lack of marine fossils and presence of coal are evidence of a shallow sea floor in southern Saskatchewan.

Price found that rocks of the Ashville contain marine fossils and include fine grained sediments, but have none of the light colored clays that according to him, seem to be associated with low salinity. He interprets these properties as indicating a return to free circulation of marine water following removal of any restriction that may have existed during deposition of the Swan River Group. This might have resulted from deepening of the water due to further subsidence.

Guliov (1967, p. 13) found that in the early stages of transgression of the Joli Fou sea through Saskatchewan it was shallow and weakly to moderately saline. A trend toward deeper more normal saline conditions is inferred from the dominance of species of Miliammina but apparently deepening was not great and the sea maintained a shallow shelf type character throughout Joli Fou time.

Stelck et al. (1956, p. 20) found that in Alberta the Haplophragmoides gigas sea contained an assemblage of finely arenaceous microfossils that indicate normal salinity and probable water depths in excess of 100 feet. This environment most likely continued into late Albian time.

The endemic faunas of the Shaftesbury Formation suggest that the sea may have been completely landlocked and may have been intermittently isolated from the major oceans (Stelck et al. 1958, p. 22). Stelck claims that the accumulation of fish scales at the top of the Albian stage in the Fort St. John area of British Columbia implies the development of a euxinic condition within the inland sea. The cessation of sea expansion was marked by the condensed bioclastic accumulation--the fish scale marker bed (Stelck et al. 1958, p. 24).

Paleontology of the Ashville Formation

Megafossils: A notable feature of the Ashville beds has been the lack of megafossils, especially a lack of reliable index specimens.

Megafauna: McLearn found poorly preserved specimens of Inoceramus in the east half of Section 24, Township 44, Range 3, West 2nd Meridian which he compared with Inoceramus dunveganensis and Inoceramus mcconnelli Warren. These fossils were recovered above a silt zone near the top of the Ashville in beds related either to the Ashville or to the overlying Favel (Wickenden 1945, p. 22). Inoceramus and oyster fragments have been found in other localities but have not been useful for correlation.

Megaflora: To date, no published record of any megaflora from the Ashville Formation has been found.

Microfossils:

Microfauna: Most of the information regarding microfossils from Ashville strata can be attributed to studies by R.T.D. Wickenden (1932a, 1932b, 1945). Microfossils studied included Foraminifera and Radiolaria. The latter were not studied in detail but were found to be

useful for local correlation as they are confined to his upper shale member. Foraminifera occur in both of Wickenden's upper and lower shale members but the assemblage in each is somewhat different. All species recovered by Wickenden had arenaceous tests and nearly all were deformed. Species identifications were not made for deformed specimens and for long ranging types such as Haplophragmoides and Ammobaculites Wickenden.

The following species of Foraminifera have been recorded from the Ashville Formation (Wickenden 1945, p. 22).

Upper Shale Member:

Haplophragmoides sp.?

Ammobaculites sp.?

Tritaxia manitobensis Wickenden

Gaudryina sp.?

Miliammina manitobensis Wickenden

Trochammina sp.?

Lower Shale Member:

Haplophragmoides sp. A

Haplophragmoides sp. B

Ammobaculites sp. A

Gaudryina sp.?

There are no common species in his two shale members, but the forms of Haplophragmoides and Ammobaculites are the same as those found in the Fort St. John Group in the Peace River District (Wickenden 1945, p. 22).

Microflora: Microfloral studies only recently have been undertaken on the Ashville strata of Saskatchewan with the publication of the first part of a two part paper on spores and pollen from the Lower Cretaceous by Steeves and Wilkins (1967). It includes only spores but as no definite location of samples or specific stratigraphic information is given it cannot be determined if the study includes the Ashville interval or not. Therefore the study is of no use for biostratigraphic comparison. The only other microfloral work published on strata of this age from Saskatchewan is a study of microplankton by R.J. Davey (1969) in which sixteen species were described in strata ranging from the top of the Swan River Group to the base of the Fish Scale Zone, strata which Davey described as Albian in age. Four other species were described from above the base of the Fish Scale Zone in strata described as Cenomanian in age. Albian species described were:

Cribroperidinium intricatum Davey

Microdinium varispinosum Davey

Hystriosphæridium difficile Manum and Cookson

Oligosphæridium complex (White) Davey and Williams

Oligosphæridium anthophorum (Cookson and Eisenack) Davey and Williams

Oligosphæridium reniforme (Tasch) Davey and Williams

Litosphaeridium siphoniphorum (Cookson and Eisenack) Davey and Williams

Tanyosphæridium variecalamum Davey and Williams

?Cleistosphæridium aciculare Davey

Coronifera oceanica Cookson and Eisenack

Cyclonephelium eisenacki Davey

Hystriosphera ramosa (Ehrenberg) var. ramosa Davey and Williams

Hystriosphera ramosa (Ehrenberg) var. multibrevis Davey and Williams

Hystriosphera ramosa (Ehrenberg) var. reticulata Davey and Williams

Gonyaulacysta exilicristata Davey

Epelidosphaeridia spinosa (Cookson and Hughes) Davey

Previous Correlations and Age Determinations

In 1892 J.B. Tyrrell referred to the Ashville strata as the "Benton" Shale and in a subsequent Geological Survey of Canada report Kirk (1929, p. 17B) suggested that the formation might be equivalent to the Graneros Formation of the Benton Shale in the United States.

Correlation and age determination on the basis of megafossils has been problematic due to the lack of diagnostic specimens. On the basis of Inoceramus dunveganensis and Inoceramus mcconnelli Warren which were recovered from a silt zone near the top of the Ashville beds, in strata which may be related either to the Favel or the Ashville, McLearn suggested a possible correlation with the upper part of the Dunvegan Formation. This would mean that these beds belong to the earliest part of the Late Cretaceous (Wickenden 1945, p. 22). On the basis of microfaunal evidence, Wickenden (1945, p. 23) considered that these correlations applied only to the upper part of the formation because the microfaunas of his two shale members are different. He considered that his lower member was more closely related to the Shaftesbury in the Peace River district. Stelck (1950) established

that Wickenden's upper shale member and the Lower Shaftesbury both carry the Miliammina manitobensis fauna which he referred to the upper Albian stage.

Wickenden (1945, p. 22) also found elements of the Haplophragmoides gigas fauna immediately above the Swan River Group in the basal Ashville beds in Manitoba. This fauna has been dated upper Albian by Stelck (1950). The age of the Fish Scale Zone has not been determined precisely in the study area. Stelck (1950) found the Miliammina manitobensis microfauna in the Lower Shaftesbury Formation of the Fort St. John area below the sands carrying abundant fish remains and the ammonite Neogastrolites which he considered to be latest Albian in age. M. manitobensis is found throughout the Ashville below the Fish Scale sands. Stelck considered that the presence of M. manitobensis indicated the Upper/Lower Cretaceous boundary was within the Fish Scale sands of the Lower Colorado Shale in Alberta and in Manitoba, the boundary could be placed within the upper Ashville Formation (Stelck 1950, pp. 54-55).

The microfloral data published by Norris (1967) on the lower Colorado of Alberta supports a late Albian age for Ashville strata below the base of the Fish Scale Zone and Davey's (1969) study of the microplankton is in accord with this age assignment. The sections studied by Steeves and Wilkins (1967) are not satisfactorily located and thus lack value for chronological purposes.

Regional Correlation: (see figure 2)

Canadian Correlatives:

Largely on the basis of elements of the Haplophragmoides gigas fauna recognized from immediately above the Swan River Group in the basal Ashville Formation the lower part of the formation has been correlated with a number of units in western Canada.

The Miliammina manitobensis fauna known from the upper Ashville Formation from outcrop areas in Manitoba (Wickenden 1945, p. 22) has also been used in combination with other fossil evidence for correlation purposes (figure 2).

Within the Ashville, a thin siltstone interval is sometimes encountered which is correlated with the Viking and other sandy units in the lower Colorado Group.

UNITED STATES CORRELATIVES: In the interior of the United States equivalents of the Ashville are found in strata assigned to the lower Colorado Group. Non-marine beds include the Bear River Formation of southern Wyoming. The Fredericksburg Group of the Gulf Coast is also correlative as is part of the Potomac Group of the Atlantic Coastal Plain (figure 2).

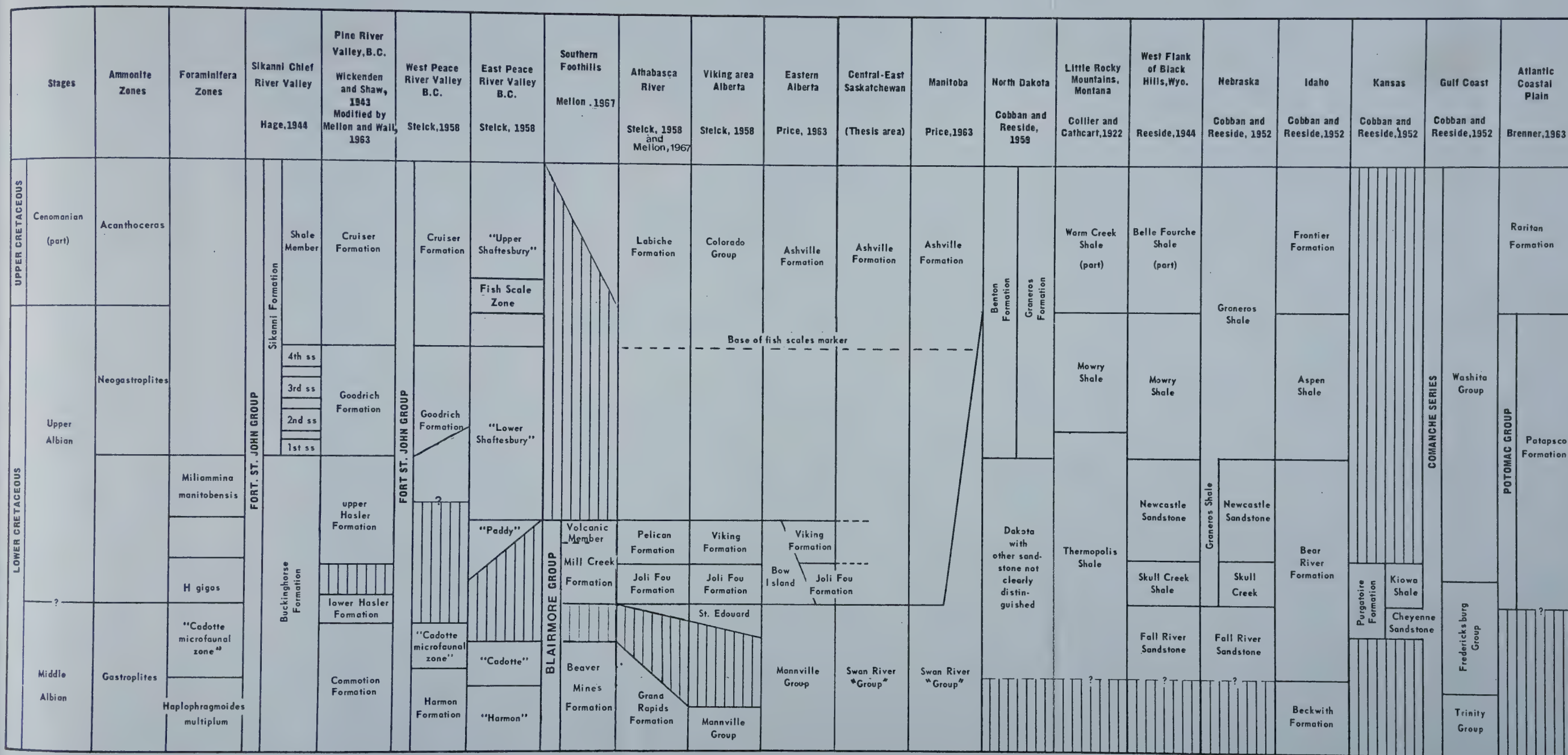


Figure 2. Correlation chart

Modified from Cobban and Reeside 1952,
Reeside and Cobban 1960, Brenner 1963,
Price 1963, Stelck 1958, Mellon and Wall
1967 and Knechtal 1959.

CHAPTER THREE - STRATIGRAPHIC PALYNOLOGY

In this chapter an attempt is made to indicate the microflora which characterize the lower Ashville Formation. Spores, pollen and microplankton were present in all samples but spore and pollen recovery was sporadic, and the number of species few, suggesting a completely marine sequence. The sporadic occurrence is unfortunate where considerable weight must be placed on key species and conclusions based on such occurrences must be tentative. Many of the species are long ranging and have little value for precise correlation and age determination. However, a few have restricted ranges and enter or leave the sequence at points above the base of the Ashville which makes them more useful. Paucity of detailed studies of late Lower Cretaceous strata, especially in Canada, limits the precision of this study and for this reason the total aspect of the assemblage is very important. It is partly this lack of detail that lends pertinence to this study.

A three-fold spore and pollen biostratigraphic division is tentatively established (figure 3). The three divisions are approximately the lateral time equivalents of the Joli Fou and Viking Formations and the overlying shale unit of the lower part of the Colorado Group of Alberta studied by Norris (1967). The divisions have been established on the basis of the first occurrence of species in each of the foregoing units.

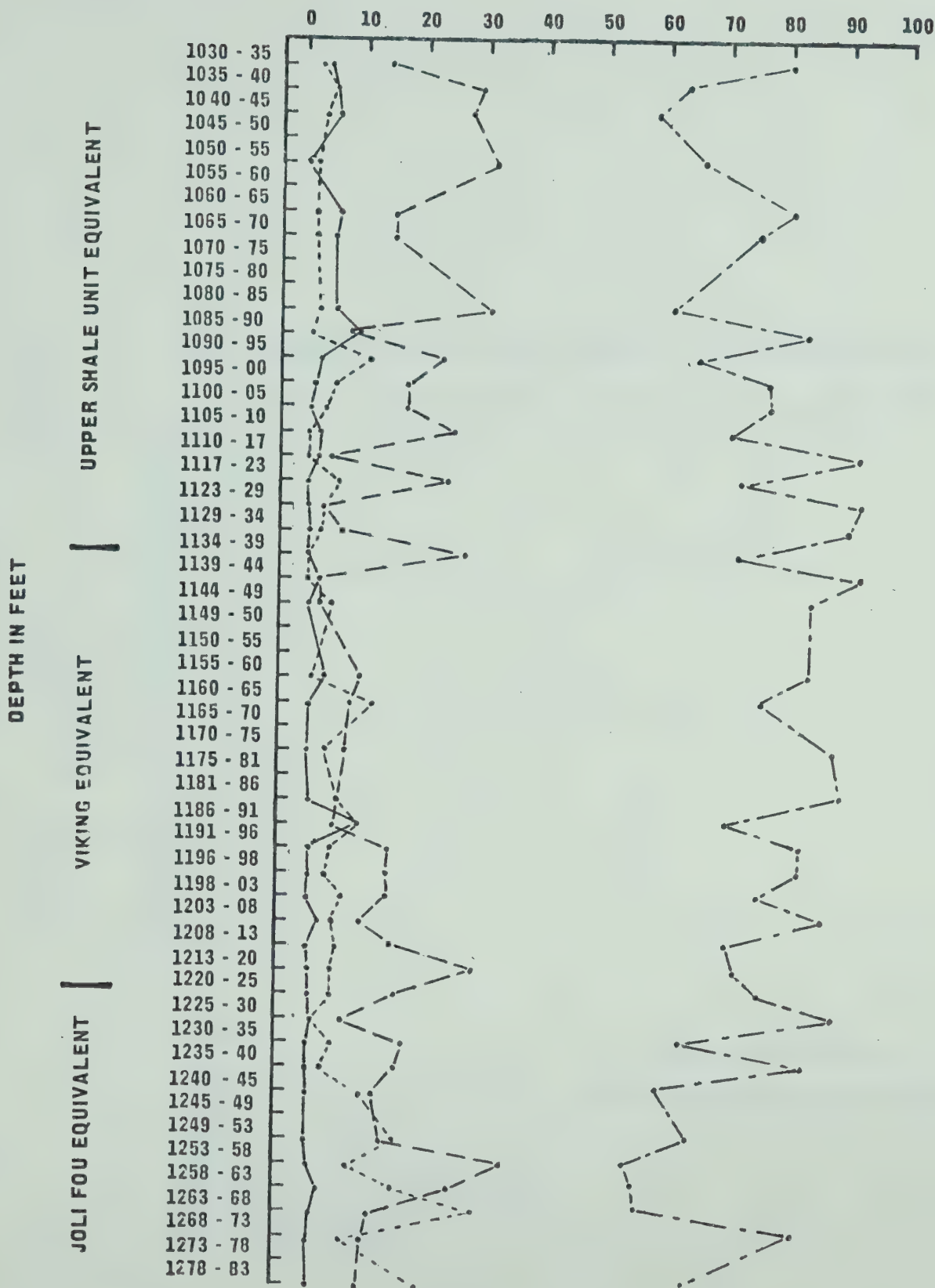
Two microplankton assemblages were found. One corresponds approximately to the Joli Fou plus the Viking Formation and the other to the overlying shale unit as established by spores and pollen in Alberta (figures 14 and 15).

The lower assemblage is characterized by numerous species, many with previously known ranges extending upward to points well below the Albian Stage. The upper assemblage is characterized by a smaller number of species and is lacking many of the species of the lower assemblage. One species, Ascodinium verrucosum, dominates the upper assemblage. Both assemblages are present in the Southwest Potash Bredenbury drill-hole but only the lower one is present in the Alwinsal Sarcee drill-hole.

Considering the planktonic habit of the phytoplankton the two-fold division of the dinoflagellates compared to the three-fold division of pollen and spores is not surprising. It is not unreasonable that the Viking interval which probably resulted from shallowing of the Colorado sea, is not reflected in specific changes in the dinoflagellate thanatocoenosis. Analysis of the percentage composition of the microplankton in the bulk microfloral assemblage (figure 4) indicates that the percentage of dinoflagellates decreased during the Viking interval in the Southwest Potash Bredenbury sequence. The decrease is interpreted as the result of changing conditions of the sea. Shallowing could also have changed marine conditions sufficiently to decrease the microplankton population. The Alwinsal Sarcee sequence on the other hand shows fluctuation in the percentage of microplankton (figure 5) in the same interval indicated as the Viking equivalent by spores and pollen, however the percentage remains high until the uppermost part of the interval. This coupled with the fact that only the lower microplankton

PERCENTAGE OF MICROFLORAL ELEMENTS IN BULK ASSEMBLAGES

20



LEGEND

ANGIOSPERMS —————

SPORES - - - - -

BISACCATE POLLEN ······

DINOFLAGELLATES ————

UNIDENTIFIED PALYNOMORPHS
MAKE UP THE REMAINDER OF THE
TOTAL PERCENTAGE

PERCENTAGES BASED ON
250 PALYNOMORPHS WHERE POSSIBLE

Figure 4 Percentage of microfloral elements in the bulk assemblages of the Southwest Potash Bredenburg drill-hole.

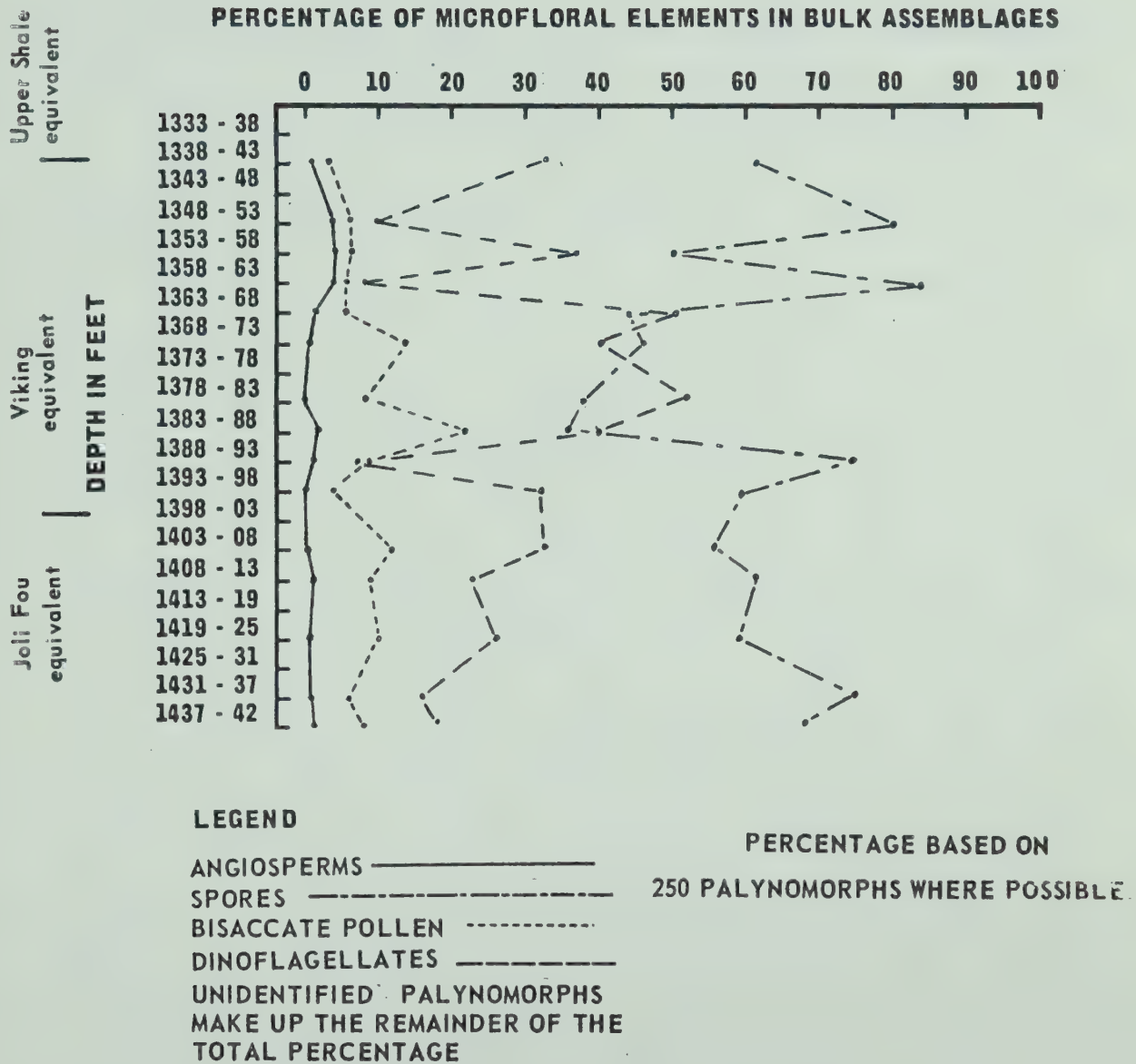


Figure 5. Percentage of microfloral elements in the bulk assemblage of the Alwinal Sarcie drill-hole

assemblage is present suggests the presence of the Colorado sea sequence of deposition only, at the Sarcee site. It suggests that significant change did not occur in the Sarcee area during the Viking time interval although some fluctuation may have occurred. The foraminiferal study of Gulioy (1967) indicates that the Haplophragmoides gigas fauna is present throughout most of the Alwinal Sarcee sequence. The microfloral evidence suggests a period of erosion and/or non deposition at the Sarcee site during or subsequent to the deposition of the upper microplankton division of the Fish Scale Zone.

The spore and pollen evidence suggests that there is a small amount of the upper shale unit time-equivalent in the Alwinal Sarcee sequence (figure 3), but there is no evidence of the upper microplankton division. This may represent diachroneity within the Ashville Formation. Within a limited geographical area where terrestrial paleoecological conditions are relatively consistent the occurrence of pollen and spores would be expected at approximately the same time horizon throughout the area. These palynomorphs would be found onshore and in adjacent marine strata. Microplankton however, being marine, would be expected to reflect changes in the marine environment (eg. transgression, regression, depth, and temperature). Thus, changes in conditions and patterns of the epicontinental seaways should be reflected in the microplankton assemblage and should be marked in time by the introduction of certain pollen and spores. Thus, within a restricted geographical area the occurrence of similar spores and pollen with differing microplankton assemblages should reflect different marine conditions. This would suggest, that restricted conditions such as those of the Mowry sea prevailed at the site of the Southwest Potash Bredenbury drill-hole at least slightly prior to their presence in the Alwinal Sarcee vicinity.

This leaves the alternatives: either open marine conditions prevailed throughout this time at the Sarcee site and/or a period of erosion and/or non deposition occurred. There is no evidence of the upper microplankton division of the Bredenbury sequence at the Sarcee site now.

A withdrawal of the epicontinental sea may have occurred subsequent to the Viking interval and prior to deposition of the Fish Scale Zone leaving only a restricted body of water in the mid-continent extending to the Bredenbury area but not as far as the Sarcee site.

The presence of angiosperm pollen in the lowest sample of the Bredenbury sequence, which is thought to lie below the Ashville Formation (Dr. G. Playford has found angiosperm in still lower samples of the Swan River Group-pers. comm.) indicates the base of the Ashville Formation is higher in stratigraphic position than the top of the Mannville Group in Alberta as no angiosperm pollen has been found in the latter. Angiosperms are known down to the base of the Colorado Group in Alberta. Many of the species found by Norris (1967) to enter the section above the base of the Colorado Group are present at the base of the Ashville Formation and this suggests that the base of the Colorado Group is diachronous although it cannot be established for certain.

Species of stratigraphic significance from both drill-hole sample sequences are listed below.

Tricolpites vulgaris (Brenner) Srivastava; known range: Upper Albian of

Maryland; ?Cenomanian of Minnesota, U.S.A.; lower part of the Colorado Group of Alberta; Albian of Oklahoma, U.S.A.

Tricolpites paraneus (Norris) n. comb.; known range; lower part of the Colorado Group of Alberta; Albian of Oklahoma, U.S.A.

Tricolpites prosimilis (Norris) n. comb.; known range: lower part of the Colorado Group of Alberta.

Tricolpites sagax Norris; known range: lower part of the Colorado of Alberta.

Tricolpites georgensis (Brenner) n. comb.; known range: upper Albian of Maryland U.S.A.; lower part of the Colorado Group of Alberta; Albian of Oklahoma, U.S.A.

Clavatipollenites minutus Brenner; known range: upper Barremian-Albian, Maryland, U.S.A.; lower part of the Colorado Group of Alberta.

Tigrisporites scurrandus Norris; known range: lower part of the Colorado Group of Alberta.

Pilosporites sp. Norris; known range: upper Albian, Maryland, U.S.A.; Viking and upper shale units of the lower part of the Colorado Group of Alberta.

Rugubivesiculites reductus Pierce; known range: upper Albian-Cenomanian of Maryland, U.S.A.; Cenomanian of Minnesota, U.S.A.; Viking and upper shale units of the lower part of the Colorado Group.

Camarozonosporites insignis Norris; known range: Viking and upper shale unit of the lower part of the Colorado Group of Alberta; upper Albian of Maryland, U.S.A. and Albian of Oklahoma, U.S.A.

Clavatipollenites hughesi Couper; known range: Barremian-Aptian, England; upper Barremian-Albian of Maryland, U.S.A.; Viking and upper shale unit of the lower part of the Colorado Group of Alberta.

?Cirratriradites teter Norris; known range: Viking and upper shale unit of the lower part of the Colorado Group of Alberta.

Cicatricosisporites hughesi Dettmann; known range: Aptian-?Cenomanian of Australia; upper shale unit of the lower part of the Colorado Group of Alberta.

Undulatisporites undulapolis Brenner; known range: upper Barremian-Albian of Maryland, U.S.A.; Albian of Oklahoma; Undulatisporites cf. undulapolis is known from the upper shale unit of the lower Colorado Group of Alberta.

Reticulisporites sp. Norris; known range: upper shale unit of the lower part of the Colorado Group of Alberta.

Psilatricolpites psilatus Pierce; known range: Cenomanian of France; ?Cenomanian of Minnesota, U.S.A.

Lycopodiumsporites reticulumsporites (Rouse) Dettmann; known range:

Middle Jurassic-Lower Cretaceous; upper shale unit of the lower part of the Colorado Group of Alberta.

The presence of Cicatricosisporites and Appendicisporites species (Brenner 1963, p. 33) places the assemblage above the Jurassic-Cretaceous boundary.

Dicotyledonous pollen is present from the base of the Ashville in both core-holes suggesting an Albian age (Brenner 1963, p. 33). The first definite dicotyledonous pollen in central Russia (Bolkhovitina 1953), New Zealand (Couper 1960), Portugal (Groot and Groot 1962), Central America and Africa (Couper 1964), Maryland (Brenner 1963), Oklahoma (Hedlund and Norris 1968) and Alberta (Norris 1967) occurs in the Albian Stage.

Spores and Pollen of the Southwest Potash Bredenburg 11-36 Drill-hole

Stratigraphically significant species include: Tricolpites vulgaris, T. paraneus, T. prosimilis, T. sagax, T. georgensis, Tigrisporites scurrandus, Pilosisorites sp. Norris, Rugubivesiculites reductus, Camarozonosporites insignis, Clavatipollenites hughesi, ?Cirratriradites teter, Cicatricosisporites hughesi, Undulatisporites undulapolis, Reticulisporites sp. Norris, Psilatricolpites psilatus and Lycopodiumsporites reticulumsorites.

The following species occur at or near the base and have not been reported from strata definitely older than late Albian in age: Tricolpites vulgaris, T. prosimilis, T. sagax, T. georgensis, T. scurrandus, Rugubivesiculites reductus, Camarozonosporites insignis, Psilatricolpites psilatus. Presence of these species suggests a late Albian age for the base of the lower part of the Ashville in this sequence.

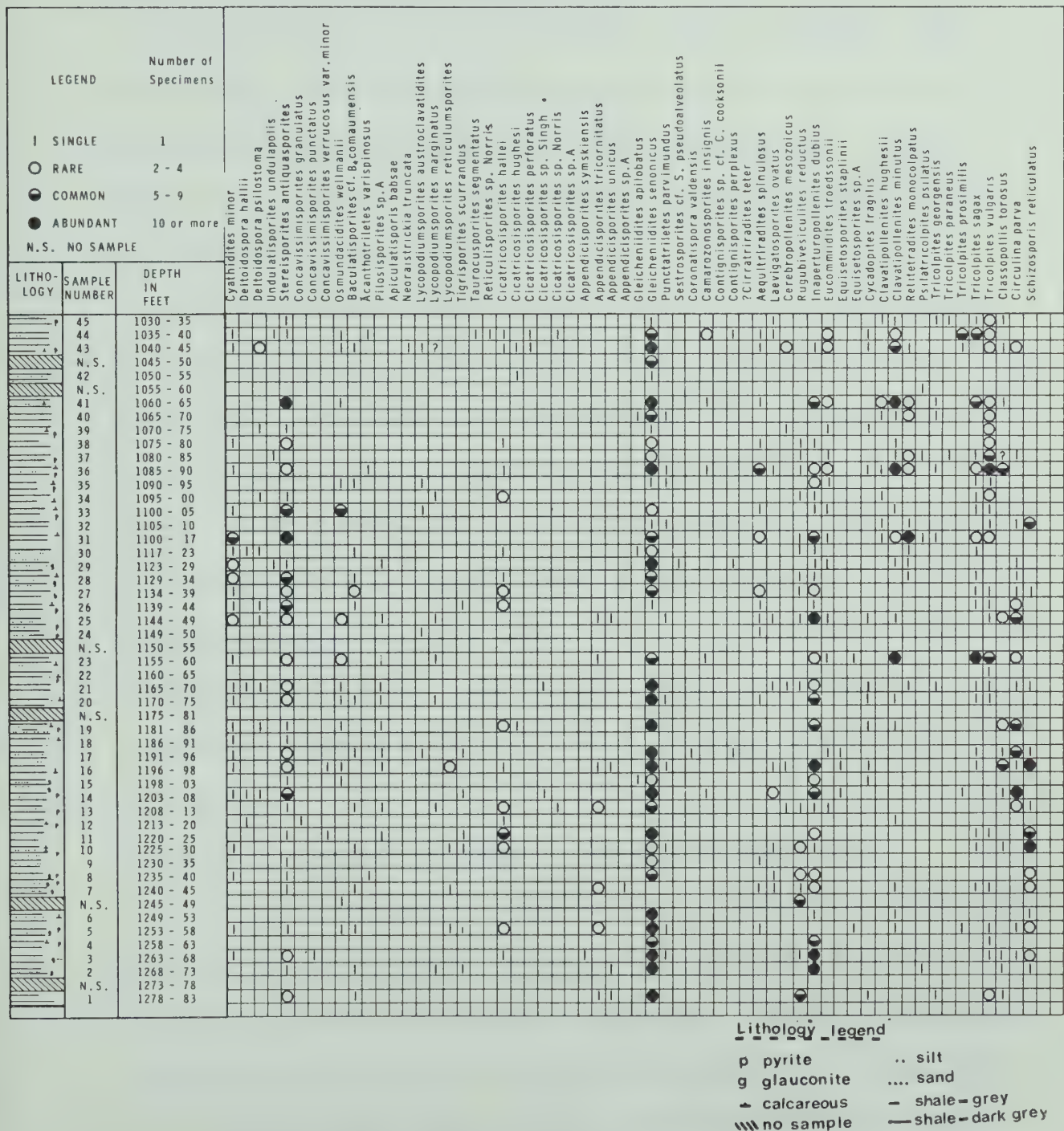


Figure 6. Distribution and relative abundance of spores and pollen in the Southwest Potash Bredenburg drill-hole

Psilatricolpites psilatus, Punctatriletes parvimundus and Rugubivesiculites reductus have previously been reported from Cenomanian strata suggesting a Cenomanian age for part of the sequence. However, Rugubivesiculites reductus has been found in the lower part of the Colorado Group of Alberta (Norris 1967) in probable late Albian strata and it is found throughout the lower part of the Ashville Formation. It is probable that the appearance of these species in the lower part of the Ashville Formation extends their known ranges to late Albian.

In Alberta the first six species listed above occur first in the Joli Fou Formation. The following six species first occur in the Viking and the remaining five species first occur in the upper shale unit. All were considered to be of probable late Albian age by Norris (1967). It is to be noted that Rugubivesiculites reductus, and Clavatipollenites hughesi found in this study, and Camarozonosporites insignis (pers. comm. Dr. Playford) have been found to range throughout the lower part of the Ashville Formation. This considerably decreases the number of species upon which to base correlation.

Spores and Pollen of the Alwinal Sarcee 4-28 Drill-hole

The spore and pollen assemblage closely resembles the Southwest Potash Bredenbury sequence. Stratigraphically significant species include Tricolpites georgensis, T. paraneus, T. sagax T. vulgaris, Clavatipollenites minutus, Tigrisporites scurrandus, Pilosporites sp. Norris, Rugubivesiculites reductus, Camarozonosporites insignis, Clavatipollenites hughesi, Undulatisporites undulapolis, and Reticulisporites sp. Norris.

As in the Southwest Potash Bredenbury sequence, angiosperms are present throughout; and on the basis of the above listed spores and pollen a late Albian age is suggested.

In the lower part of the Colorado Group of Alberta (Norris 1967) the first six species listed above occur first in the Joli Fou Formation, the next four species enter first in the Viking Formation and the last two listed species first occurred in the upper shale unit.

Microplankton

Due to lack of detailed studies of microplankton from the late Lower Cretaceous, biostratigraphic interpretation of the assemblage has been based largely on its total aspect rather than upon key species.

Microplankton of the Southwest Potash Bredenbury 11-36 Drill-hole

The stratigraphic position and relative abundance of each species is recorded on figure 8. The most striking feature of the sequence is an abrupt change in the assemblage which occurs at approximately 1134-1139. A number of species disappear; some occur for the first time and continue upward while others appear only briefly.

The Alwinsal Sarcee assemblage is comparable to the Southwest Potash Bredenbury sequence below 1134-1139 feet. Of thirty-nine species which occur only below 1134 feet in the Bredenbury drill-hole thirty-seven are found in the Sarcee drill-hole. The two which are absent in the Sarcee drill-hole are Hystriosphera ramosa var. gracilis and Scriniodinium campanula.

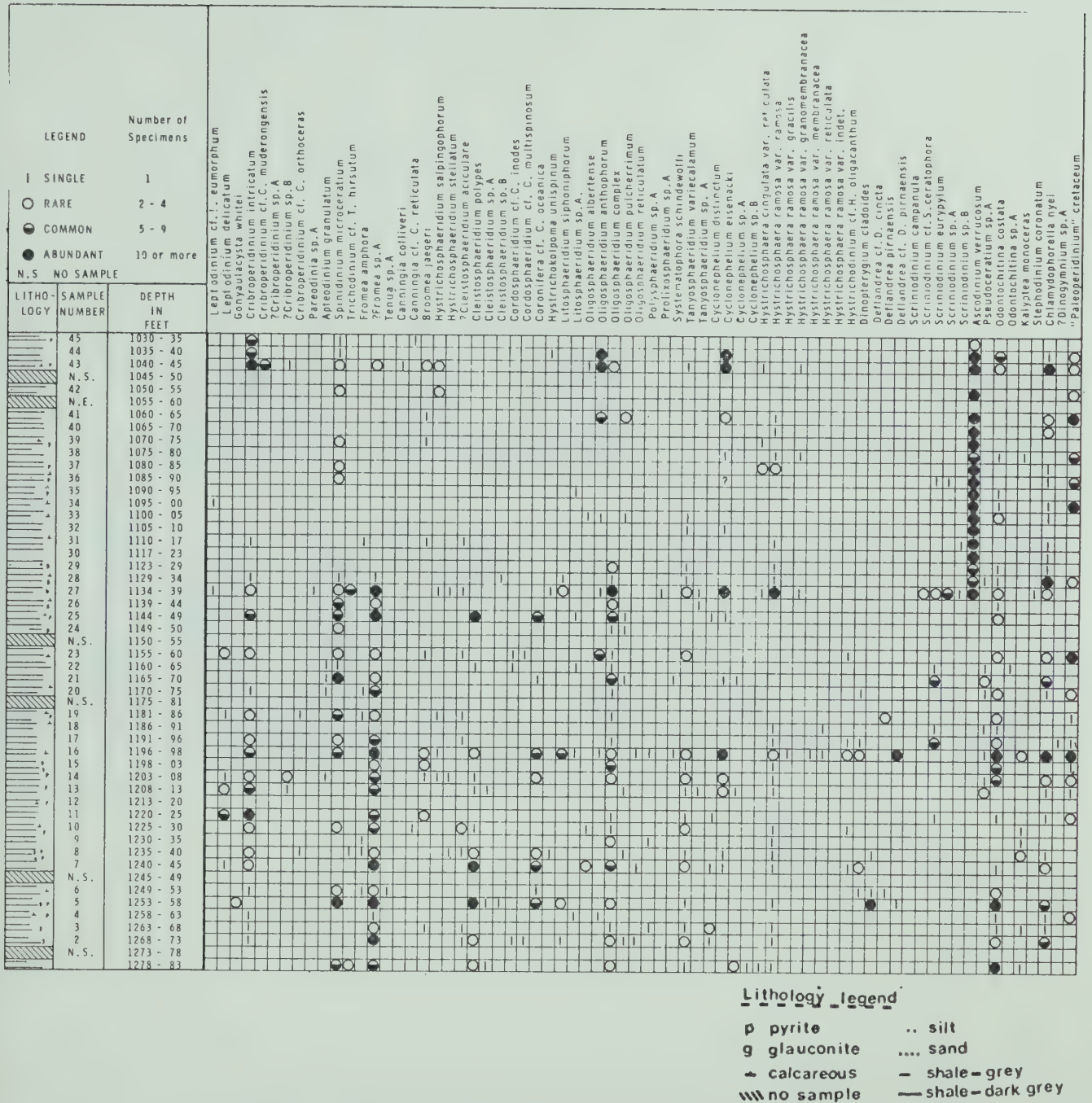


Figure 8. Distribution and relative abundance of dinoflagellates in the Southwest Potash Bredenburg drill-hole

	<i>Leptodinium delicatum</i>	
	<i>Gonyaulacysta whitei</i>	
	<i>Cribroperidinium</i> sp. B	
	<i>Aptedinium granulatum</i>	
	<i>Trichodinium</i> cf. <i>T. hirsutum</i>	
	? <i>Fromea</i> sp. A	
	<i>Tenua</i> sp. A	
	<i>Cannigia</i> cf. <i>C. reticulata</i>	
	<i>Cleistosphaeridium</i> polypes	
	<i>Cleistosphaeridium</i> sp. A	
	<i>Cordosphaeridium</i> cf. <i>C. inodes</i>	
	<i>Cordosphaeridium</i> cf. <i>C. multispliosum</i>	
	<i>Coronifera</i> cf. <i>C. oceanica</i>	
	<i>Litosphaeridium siphoniphorum</i>	
	<i>Oligosphaeridium reticulatum</i>	
	<i>Polysphaeridium</i> sp. A	
	<i>Systematophora schindewolfi</i>	
	<i>Tanysphaeridium</i> sp. A	
	<i>Cyclonephellium distinctum</i>	
	<i>Cyclonephellium</i> sp. A	
	<i>Cyclonephellium</i> sp. B	
	<i>Hystriichosphaera ramosa</i> var. <i>membranacea</i>	
	<i>Hystriichosphaera ramosa</i> var. <i>reticulata</i>	
	<i>Hystriichodinium</i> cf. <i>H. oligoconthum</i>	
	? <i>Dinopterygium cladoides</i>	
	<i>Deflandrea</i> cf. <i>D. cincta</i>	
	<i>Deflandrea pinnaensis</i>	
	<i>Deflandrea</i> cf. <i>D. pinnaensis</i>	
	<i>Pseudoceratium</i> sp. A	
	<i>Odontochitina</i> sp. A	
	? <i>Dinogymnium</i> sp. A	
Oligocene		
Eocene		
Paleocene		
Senonian		
Turonian		
Cenomanian		
Albian		
Aptian		
Neocomian		
Jurassic		

Figure 10. Species of dinoflagellates below 1134 feet in the Southwest Potash Bredenbury drill-hole.

	<i>Leptodinium</i> cf. <i>L. eumorphum</i>	
	<i>Paradina</i> sp. B	
	<i>Prolixosphaeridium</i> sp. A	
	<i>Hystriichosphaera cingulata</i> var. <i>reticulata</i>	
	<i>Hystriichosphaera ramosa</i> var. <i>granomembranacea</i>	
	<i>Scribneridium</i> cf. <i>S. ceratophora</i>	
	<i>Scribneridium</i> sp. A	
	<i>Scribneridium</i> sp. B	
	<i>Ascodinium verrucosum</i>	
	<i>Stephodinium coronatum</i>	
Oligocene		
Eocene		
Paleocene		
Senonian		
Turonian		
Cenomanian		
Albian		
Aptian		
Neocomian		
Jurassic		

Figure 11. Species of dinoflagellates at or below 1134-1139 feet in the Southwest Potash Bredenbury drill hole

	Oligocene	Eocene	Paleocene	Senonian	Turonian	Cenomanian	Albian	Aptian	Neocomian	Jurassic
<i>Cribopteridium intricatum</i>										
<i>Cribopteridium</i> sp. A										
<i>Spinidium microceratium</i>										
<i>Fromea omphora</i>										
<i>Caninia colliveri</i>										
<i>Hystriosphoeridium salpingophorum</i>										
<i>Pleisosphoeridium oculare</i>										
<i>Hystriochokolpoma unispinum</i>										
<i>Litosphaeridium</i> sp. A										
<i>Oligosphaeridium albertense</i>										
<i>Oligosphaeridium anthophorum</i>										
<i>Oligosphaeridium complex</i>										
<i>Oligosphaeridium pulcherrimum</i>										
<i>Tonosphaeridium varicellatum</i>										
<i>Cyclonophellium eisenacki</i>										
<i>Hystriosphoera ramosa</i> var. <i>ramosa</i>										
<i>Scribneridium eurypylum</i>										
<i>Kalypsea monoceras</i>										
<i>Odontochitina costata</i>										
<i>Chlamydophorella nyel</i>										
<i>"Poliopteridium" cretaceum</i>										
<i>Broomia laegeri</i>										

Figure 12. Species of dinoflagellates that range throughout the Southwest Potash Bredenbury drill-hole

	Leptodinium delicatum
	Cribroperidinium intricatum
	Cribroperidinium cf. C. orthoceras
	Apteodinium granulatum
	Spinidinium microceratium
	Trichodinium cf. T. hirsutum
	?Fromea sp. A.
	Broomea jaegeri
	Hystrichosphaeridium salpingophorum
	?Cleistosphaeridium aciculare
	Cleistosphaeridium polypes
	Coronifera cf. C. oceanica
	Hystrichokolpoma unispinum
	Litosphaeridium siphoniphorum
	Oligosphaeridium albertense
	Oligosphaeridium anthophorum
	Oligosphaeridium complex
	Oligosphaeridium pulcherrimum
	Oligosphaeridium reticulatum
	Polysphaeridium sp. A.
	Systematophora schindewolfi
	Tanyosphaeridium variecalamum
	Cyclonephelium distinctum
	Cyclonephelium eisenacki
	Hystrichosphaera ramosa var. ramosa
	Hystrichosphaera ramosa var. gracilis
	Hystrichosphaera ramosa var. granomembranacea
	Hystrichosphaera ramosa var. Indet.
	Hystrichodinium cf. H. oligacanthum
	?Dinopterygium cladoides
	Deflandrea cf. D. cincta
	Deflandrea pirmaensis
	Scribnerioidinium campanula
	Scribnerioidinium eurypylum
	Odontochitina costata
	Kalypteo monaceras
	Chlamydophorella nyel
	"Paleoperidinium" cretaceum
Oligocene	
Eocene	
Paleocene	
Senonian	
Turonian	
Cenomanian	
Albian	
Aptian	
Neocomian	
Jurassic	

Figure 13. Species of dinoflagellates in the Alwinal Sarcee drill-hole

Of ten species recorded from only above 1134 feet in the Bredenbury drill-hole only one occurs in the Sarcee drill-hole. This species is Hystriosphera ramosa var. granomembranacea.

The upper microplankton assemblage has fewer species than the lower assemblage with Ascodinium verrucosum becoming the most dominant species. This may indicate an abrupt change in the marine environment, resulting in the dominance of only a few species. This interpretation seems to support Stelck et al. (1958, p. 22) who stated, "... restriction of the faunas of the Shaftesbury Formation to the interior of North America suggests this sea was almost completely landlocked and may have been intermittently isolated from the major oceans of the world."

The presently known ranges of the microplankton species listed here probably reflect gaps due to lack of study. It is considered that any attempt to date the Ashville strata precisely on their presence alone would be premature in view of the present knowledge of microplankton ranges.

ALWINSAL SARCEE
4 - 28

SOUTHWEST POTASH BREDBURY
11 - 36

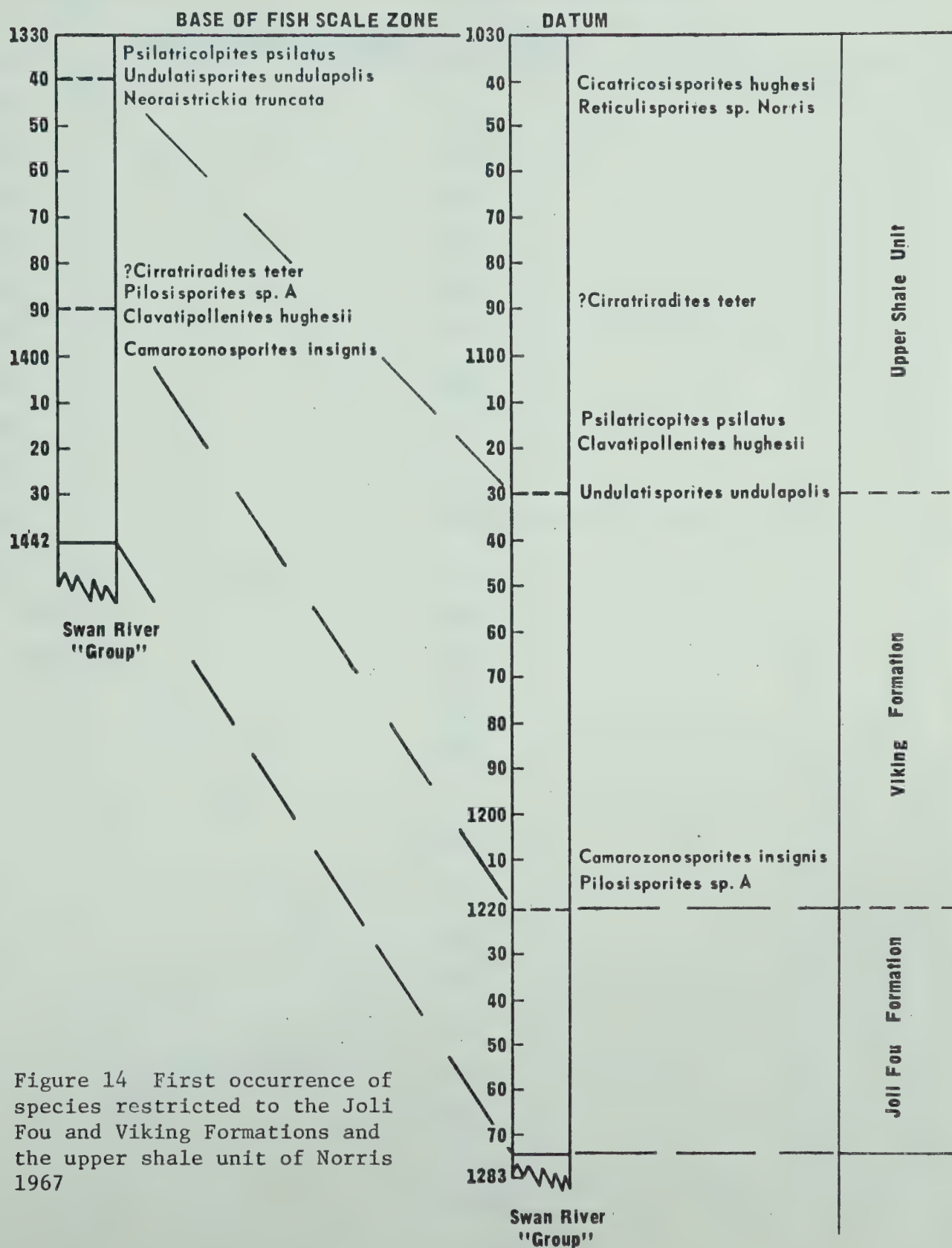
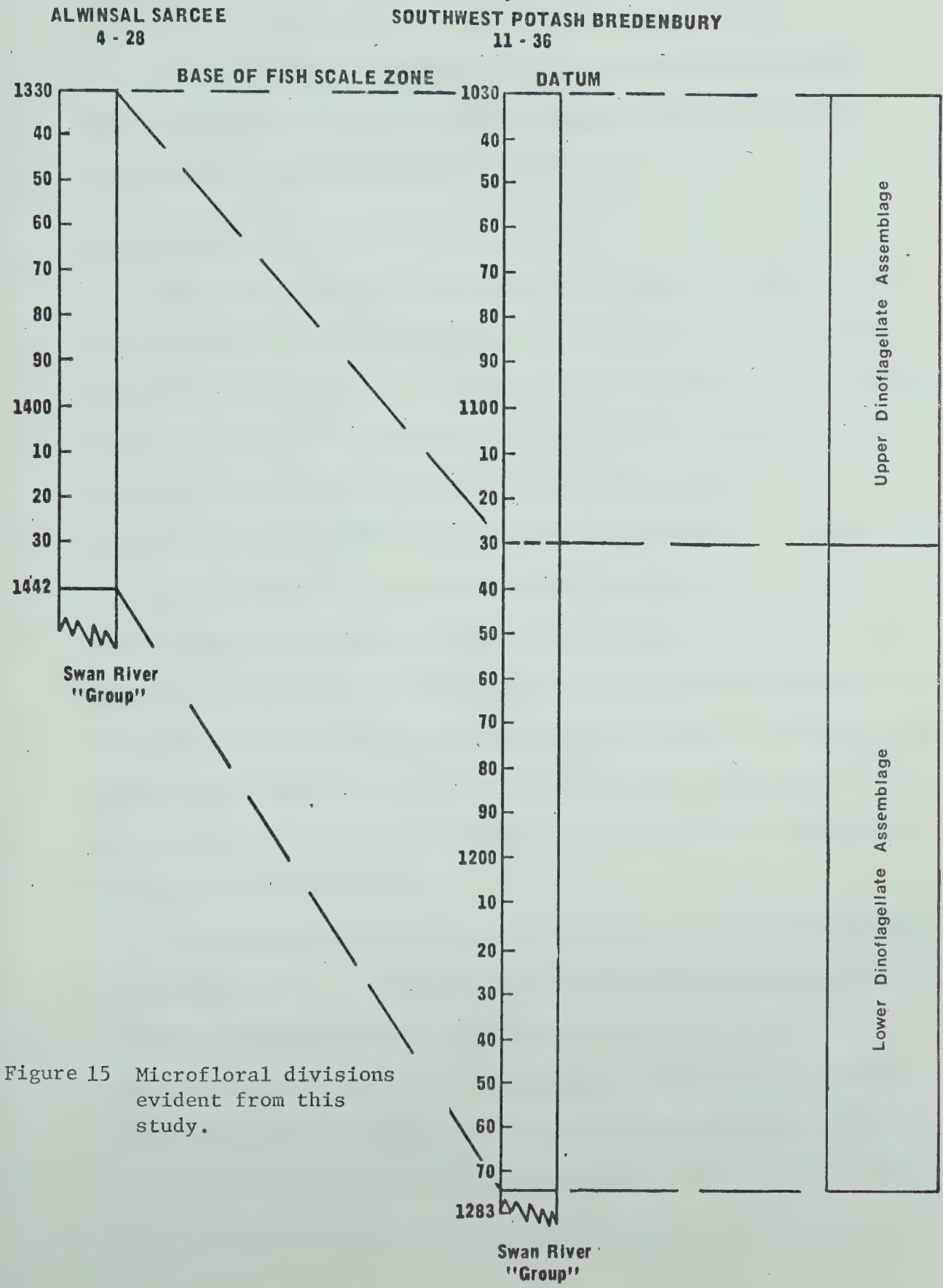


Figure 14 First occurrence of species restricted to the Joli Fou and Viking Formations and the upper shale unit of Norris 1967



CHAPTER FOUR - AGE AND CORRELATION OF THE LOWER PART OF THE ASHVILLE FORMATION

The microfloral content of the two drill-hole sequences is compared to some previously described assemblages to demonstrate stratigraphic and chronological relationships.

Spores and Pollen

The most comparable assemblage to the Ashville assemblage is that studied by Norris (1967) from the lower part of the Colorado Group of Alberta. Forty of seventy-six species from Alberta (excluding bisaccate species) are found in the strata of this study (figure 16). Of eighty-seven species reported in the underlying Grand Rapids Formation by Singh (1964), Norris found that forty-seven ranged into the Lower Colorado Group and forty were restricted to the Grand Rapids. Only two species of the forty restricted to the Grand Rapids in Alberta were found in the lower part of the Ashville Formation in this study. They are Concavissimisporites punctatus, and Aequitriradites spinulosus. Twenty-three of the forty-seven long ranging species are found in the Ashville Formation. Species with more restricted ranges are discussed below.

Of nine species (excluding two bisaccate pollen species) that first appeared in the Joli Fou unit of Alberta, seven species are recorded from the lower part of the Ashville Formation. Of five species (excluding three bisaccate pollen species) first appearing in the Viking Formation in Alberta all are recorded from Ashville strata, and of eighteen species recovered only from the upper shale unit in Alberta four are present in the Ashville in Saskatchewan.

The species have been listed previously and indicate a probable late Albian age for the lower Colorado in Alberta and the lower Ashville in eastern Saskatchewan. The base of the Ashville is however, probably younger than the base of the Joli Fou.

Studies by Pocock (1962,1965) on the Jurassic-Cretaceous boundary of western Canada and the Mannville Group in Saskatchewan, like the study of the Mannville Group by Singh (1964) indicate numerous long ranging forms present which are found in the Ashville strata of this study (figure 16). No angiosperms were found in the Mannville and the number of Schizaceae species was considerably greater than the number found in this study. All of these facts indicate that the Ashville Formation is younger than the Mannville strata of middle Albian age.

Comparison with Biostratigraphic Units in the United States

Many of the spores and pollen recovered from Ashville strata have counterparts in the Potomac Group of Maryland and Delaware (Brenner 1963,1967). Zone II (in particular Zone IIb) of Brenner (1963) corresponds to the lower part of the Ashville Formation of this study. Species common to the Ashville are shown on figure 16. Of the species found in the Ashville the following are restricted to Brenner's Zone II: Apiculatisporis babsae Brenner, Lycopodiumsporites austroclavatidites (Cookson) Potonié, Tricolpites georgensis (Brenner) n. comb., Cerebropollenites mesozoicus (Couper) Nilsson. The Ashville assemblage contains Rugubivesiculites reductus which is restricted to Brenner's Zone IIb and angiosperm pollen is restricted to his Zone II.

Brenner (1963, p. 33) has assigned an Albian age to the strata suggesting that Zone II is at least in part of late Albian age.

Hedlund and Norris (1968) recorded eighty species of fossil pollen and spores from the "Walnut" - Antlers Formations of Oklahoma. Seventeen of the species are found in the Ashville Formation (figure 16). Species found in the "Walnut" - Antlers assemblage that are also common to the Potomac Group and the lower part of the Ashville strata are: Undulatisporites undulapolis Brenner, Clavatipollenites minutus Brenner, Tricolpites georgensis (Brenner) n. comb., Circulina parva Brenner. These species have previously been found to have an exclusively Lower Cretaceous distribution in North America (Hedlund and Norris 1968, p. 154).

Forms common to the lower part of the Colorado Group of Alberta, to the "Walnut" - Antlers assemblage and to the lower part of the Ashville Formation which have not been reported from strata younger than Albian or older than Early Cretaceous in North America are: Undulatisporites undulapolis Brenner, Clavatipollenites minutus Brenner, Tricolpites georgensis (Brenner) n. comb., T. paraneus Norris and Circulina parva Brenner.

Three of nine species listed by Hedlund and Norris, presently restricted to Albian strata in North America, occur in the Ashville Formation. They are Tricolpites sagax Norris, Tricolpites georgensis (Brenner) n. comb., and T. paraneus (Norris) n. comb.

Hedlund and Norris cite the presence of dicotyledonous pollen as evidence that the "Walnut" - Antlers assemblage is younger than the late Barremian to middle Albian Mannville Group (Pocock 1962, 1965;

Singh 1964; Norris 1967) and younger than the Patuxent and Arundel Formations of Maryland (Brenner 1963,1967), which do not contain angiosperm pollen. This suggests that the Ashville strata studied here are also younger than middle Albian. The presence of more complex "advanced" dicotyledonous types such as tetra and pentacolpate grains in the "Walnut" - Antlers assemblage is taken by Hedlund and Norris (1968) as indicating a post Albian age were not found in the Ashville strata of this study however. These forms perhaps reflect different paleoecological conditions in the two areas since it is considered that the strata in the two areas are coeval in part. Further information is needed before more positive statements can be made.

The possible Cenomanian assemblage of species illustrated by Pierce (1961) from Minnesota has only Rugubivesiculites reductus, Psilatricolpites psilatus, Tricolpites vulgaris, Retitetradites monocolpatus and Punctatriletes parvimumundus in common with the lower Ashville assemblage and the presence of tricolporate pollen grains suggests that the Minnesota strata are younger.

Few similarities exist between the Ashville assemblage and other palynomorph studies from the Upper Cretaceous deposits of the Atlantic Coastal Plain (Leopold and Pakiser 1964, Hedlund 1966), and New Mexico (Anderson 1960). All of these studies report dicotyledonous porate and colpate grains which are not present in the lower part of the Ashville Formation.

Comparison with Spore and Pollen Assemblages Outside North America

No angiosperm pollen has been found in Jurassic, Wealden or Aptian (Lower Greensand) strata of Britain (Couper 1958), in Jurassic or Cretaceous strata in Germany (Thiergart 1949), or in Lower Cretaceous sediments in Russia (Bolkhovitina 1953,1959). A number of the long ranging species illustrated by Couper (1953) have counterparts in the lower Ashville strata.

Australian studies of interest have been made on Valanginian or older strata by Balme (1957) and on sediments ranging from Aptian to Albian age (Dettmann 1963). A few long ranging species reported by Dettmann are found in the Ashville (figure 16). Dettmann noted a few angiosperm pollen grains entering the sequence in some Albian samples. Both sequences are considered older than the assemblage described here.

Comparison of Microplankton with Previously Described Assemblages

Davey (1969) in Part I of a two part series described and illustrated sixteen species of microplankton from Albian and Cenomanian strata in a drill-hole about 12 miles south of the Bredenbury drill-hole used in this study. Eleven of his species have been recorded in this study and are listed on figure 17. The Albian and Cenomanian boundaries accepted by Davey were not based on the microplankton he found but on other evidence. Most of his species are known to range from Lower to Upper Cretaceous. Leptodinium delicatum found only in the Cenomanian samples studied by Davey, appears in Albian strata in this study.

Eight of the forty-nine species reported by Manum and Cookson (1964) from the lowermost Upper Cretaceous in the Canadian Arctic occur in Ashville strata and are listed on figure 17.

All but two species Pareodinia sp. A and Stephodinium europaicum (= Stephodinium coronatum), occur below 1134-1139 feet. Although the rest of the assemblage is not comparable to the Ashville suite, the similarity suggests that similar paleoecological conditions existed in the two areas.

Pocock (1962) and Singh (1964) described microplankton from Jurassic to Cretaceous and from late Barremian to middle Albian strata of western Canada respectively. Of six species described by Pocock and ten described by Singh that range into the lower Ashville strata, all occur below 1134-1139 feet in the Bredenbury sequence.

The Ashville strata are characterized by a dramatic increase in the number of species as compared to older strata in Alberta (Pocock 1962, Singh 1964) although the numbers decrease markedly in the upper part of the beds studied here.

Comparisons with Microplankton Assemblages Outside Canada

Few published studies of Cretaceous microplankton from the United States were encountered. Tasch et al. studied the Kiowa Shale of Albian age in Kansas which was found to contain an anomalous assemblage different from the assemblage described here or any other Albian assemblage known at present. As these authors note, this may be a geographic phenomenon with the assemblage representing a distinct paleogeographical province (Tasch et al., 1964, p. 196).

The forms reported by Drugg (1967) from Cretaceous to Paleocene rocks in California differ from the forms encountered in this study.

Ascodinium cf. A. verrucosum was reported from Lower Cretaceous sediments of Montana by Evitt (1967a) but little published information is available for biostratigraphic correlation.

The most comparable assemblage to the Ashville suite from outside Canada is that of the upper Gault, Cambridge Greensand and Chalk Marl of Britain described by Cookson and Hughes (1964). Twelve of thirty-eight described species are found in the lower Ashville (figure 12) and the two suites are probably at least partially correlative. Unfortunately, whether the Cambridge Greensand belongs to the varians subzone (lower Cenomanian) or the dispar subzone (uppermost Albian) is still controversial thus preventing a direct calibration with the standard European ammonite sequence.

Davey et al. (1966) have described eighteen species from Mesozoic and Cenozoic sediments of Britain which also occur in the Ashville Formation (figure 12). Ten species have not previously been found in strata as old as Albian and it is thought that their occurrence in the lower Ashville extends their known ranges.

The Ashville assemblage does not appear to correlate with Clarke and Verdier's (1967) study from the Isle of Wight, although long ranging species are present (figure 17).

Of seventy-five species of fossil microplankton from Upper Jurassic and Cretaceous Aptian, Albian, Cenomanian and Campanian strata from Australia and New Guinea (Cookson and Eisenack 1958) only six are common to the Ashville assemblage. None of forty-three species from upper Albian to Campanian strata of Australia (Cookson and Eisenack (1960a) occur in the Ashville. The Ashville assemblage includes six of the thirty-six species described by

**COMPARISON OF SELECTED STUDIES WITH SPORES
AND POLLEN FROM THE LOWER PART OF
THE ASHVILLE FORMATION**

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	Albian - ? Cenomanian Norris 1967	Barremian to Middle Albian Singh 1964	Upper Jurassic to Neocomian Pocock 1962	Lower Cretaceous Steeves and Wilkins 1967	? Cenomanian Pierce 1961	Barremian to Upper Albian Brenner 1963	Albian Hedlund and Norris 1968	Lower Lias to Aptian Couper 1958	Valanginian - Aptian and Aptian - Albian Deftmann 1963
Cyathidites minor	•	•	•			•	•		•
Deltoidospora hallii	•	•	•			•		•	
Deltoidospora psilostoma	•	•	•						
Undulatisporites undulapolis						•	•		
Stereisporites antiquasporites	•	•	•	•		•			•
Concavissimisporites granulatus									
Concavissimisporites punctatus		•	•			•		•	
Concavissimisporites verrucosus var. minor									
Osmundacidites wellmanii	•	•	•					•	•
Baculatisporites cf. B. comaumensis	•						•	•	•
Acanthotriletes varispinosus	•	•	•						
Pilosporites sp. A	•								
Apiculatisporis babsae						•			
Neoraistrickia truncata	•								•
Lycopodiumsporites austroclavatidites	•	•	•			•			•
Lycopodiumsporites marginatus	•	•					•		
Lycopodiumsporites reticulumsporites	•								•
Tigrisporites scurrandus	•								
Taurocusporites segmentatus	•	•		•		•	•		
Reticulisporites sp. A	•								
Cicatricosisporites hallei	•					•	•		
Cicatricosisporites hughesi	•								•
Cicatricosisporites perforatus		•							
Cicatricosisporites sp. Singh		•							
Cicatricosisporites sp. Norris	•								
Cicatricosisporites sp. A									
Appendicisporites symskiensis									
Appendicisporites tricornitatus		•	•			•	•		
Appendicisporites unicus	•	•							
Appendicisporites sp. A									
Gleicheniidites apilobatus						•			
Gleicheniidites senonicus	•	•	•	•		•	•	•	
Punctatriletes parvimundus					•				
Sestrosporites cf. S. pseudoalveolatus								•	
Coronatispora valdensis	•								
Camarozonosporites insignis	•						•		
Contignisporites cf. C. cooksonii									•
Contignisporites perplexus	•	•							
?Cirratriletes teter	•								
Aequitriletes spinulosus		•	•	•		•			•
Laevigatosporites ovatus	•	•	•				•		
Cerebropollenites mesozoicus	•	•	•			•		•	•
Rugubivesiculites reductus	•			•	•	•			
Inaperturapollenites dubius	•					•		•	
Eucommilites troedssonii	•	•	•			•		•	
Equisetosporites staplinii									
Equisetosporites sp. A									
Cycadopites fragilis	•	•							
Clavatipollenites hughesi	•					•	•	•	
Clavatipollenites minutus	•					•			
Retitetradites monocarpatus					•				
Psilatricolpites psillatus					•				
Tricolpites georgensis	•					•	•		
Tricolpites paraneus	•						•		
Tricolpites proximilis	•				•				
Tricolpites sagax	•								
Tricolpites vulgaris	•						•		
Classopollis torosus	•					•	•	•	
Circulina parva	•					•	•		
Schizosporites reticulatus	•	•	•			•	•		•

Figure 16

**COMPARISON OF SELECTED STUDIES WITH
DINOFLAGELLATES FROM THE LOWER PART
OF THE ASHVILLE FORMATION**

	Albian/Cenomanian Davey 1969	Lower Upper Cretaceous Manum and Cookson 1964	Paleocene Stanley 1965	Albian Tasch, McLure and Offedahl 1964	Upper Gault Cookson and Hughes 1964	Greensand Cookson and Hughes 1964	Chalk Marl Cookson and Hughes 1964	Hauterivian/Barremian (Gocht 1957, 1959; Alberti 1961)	Mesozoic and Cainozoic Davey et al. 1966	Aptian Eisenack 1958	Cenomanian Turonian and Senonian Clarke and Verdier 1967	Albian Battres 1967	Cookson and Eisenack 1958	Cookson and Eisenack 1962
Leptodinium cf. L. eumorphum														
Leptodinium delicatum	•													
Gonyaulacysta whitei									•					
Cribroperidinium intricatum	•													
Cribroperidinium cf. C. muderongensis														
Cribroperidinium cf. C. orthoceras									•					
Cribroperidinium sp. A												•		
Cribroperidinium sp. B														
Pareadinia sp. A														
Aptedinium granulatum			•											
Spinidinium microceratium														
Trichodinium cf. T. hirsutum														
Fromea amphora		•			•			•	•	•		•	•	•
?Fromea sp. A														
Tenua sp. A														
Canningia colliveri														
Canningia cf. C. reticulata														
Broomea jaegeri														
Hystrichosphaeridium salpingophorum									•		•		•	
Hystrichosphaeridium stellatum		•			•	•	•						•	
?Cleistosphaeridium aciculare	•													
Cleistosphaeridium polypes					•	•	•				•			
Cleistosphaeridium sp. A														
Cleistosphaeridium sp. B									•					
Cordosphaeridium cf. C. Inodes	•													
Cordosphaeridium cf. c. multispinosum														
Coranifera cf. C. oceanica	•		•		•	•		•		•	•			•
Hystrichokolpoma unispinum									•					
Litosphaeridium siphoniphorum	•				•	•			•		•	•		
Litosphaeridium sp. A														•
Oligosphaeridium albertense														
Oligosphaeridium anthophorum	•													
Oligosphaeridium complex	•				•	•	•	•	•	•	•			•
Oligosphaeridium pulcherrimum									•		•			
Oligosphaeridium reticulatum									•					
Polysphaeridium sp. A									•					
Systematophora schindewolfi														
Tanyosphaeridium variecalamum	•								•					
Tanyosphaeridium sp. A														
Cyclonephellium distinctum		•									•		•	
Cyclonephellium eisenacki	•													
Cyclonephellium sp. A														
Cyclonephellium sp. B														
Hystrichosphaera cingulata var. reticulata									•					
Hystrichosphaera ramosa var. ramosa	•								•					
Hystrichosphaera ramosa var. gracilis									•					
Hystrichosphaera ramosa var. granomembranacea									•					
Hystrichosphaera ramosa var. membranacea									•					
Hystrichosphaera ramosa var. reticulata	•								•					
Hystrichosphaera ramosa var. Indet														
Hystrichodinium cf. H. oligacanthum														
?Dinopterygium cladaides														
Deflandrea cf. D. cincta														
Deflandrea pirnaensis														
Deflandrea cf. D. pirnaensis														
Seriniadinium campanula					•	•	•	•		•	•			
Seriniadinium cf. S. ceratophora														
Seriniadinium eurypylum		•												
Seriniadinium sp. A														
Seriniadinium sp. B														
Ascadinium verrucosum						•	•					•		
Pseudoceratium sp. A														
Odontochitina costata		•			•				•		•		•	
Odontochitina sp. A														
Kalyptea monaceras		•			•	•	•				•	•		
Stephodinium coronatum					•		•						•	•
Chlamydophorella nyel		•				•								
?Dinogymnium sp. A														
"Paleoperidinium" cretaceum		•									•			

Figure 17.

Cookson and Eisenack (1962a) from Aptian to Cenomanian strata in Australia. These assemblages appear to represent a different phytoplankton province.

The only European assemblage similar to the Ashville assemblage is from the Moesic Platform of Rumania (Baltes 1967). Five of twenty-two species from strata assigned to the Albian Stage by Baltes are found in the Ashville (figure 12). His Ab. 1 and Ab. 2 complexes cannot be distinguished in Saskatchewan but elements are present from both complexes and support the Albian age assigned to the lower part of the Ashville.

Summary

On the basis of the microflora studied, the Alwinal Sarcee sequence is considered equivalent to that part of the Southwest Potash Bredenburg sequence below 1134-1139 feet. The lower part of the Ashville Formation is correlative with the late Albian lower part of the Colorado Group of Norris (1967) and with the lower Colorado sequence below the base of the Fish Scale Zone described by Davey (1969). The sequence is younger than the late Barremian to middle Albian Mannville Group (Singh 1964) and the upper Mannville studied by Pocock (1965).

In the United States, Zone IIb (Brenner 1963) considered equivalent to the upper two-thirds of the Patapsco Formation of Maryland, is probably coeval with the lower part of the Ashville. This zone has been assigned an Albian age possibly in part of late Albian age.

The Albian "Walnut" - Antlers assemblage from Oklahoma (Hedlund and Norris 1968) is probably partially equivalent to the strata of this study. More complex "advanced" (Hedlund and Norris 1968, p. 156) angiosperms may reflect paleoecological differences rather than age differences.

Ashville microplankton appear to correlate with part of the Chalk Marl, Cambridge Greensand, and upper Gault strata which are either late Albian or Early Cenomanian. Albian strata from Rumania also carry a somewhat comparable assemblage.

CHAPTER FIVE - BOTANICAL RELATIONS AND PALEOECOLOGICAL INTERPRETATIONS OF THE SPORES AND POLLEN

Comparative morphological studies of recent plants and fossil spores and pollen offer suggestions of the natural affinities of fossil spores and pollen even though the affinities cannot be established for certain unless they are found associated with at least part of the parent plant. On the basis of affinities suggested in works by Couper (1958), Groot et al. (1961), Pocock (1962,1965), Potonié (1962,1967), Dettmann (1963), Brenner (1963), Singh (1964), and Norris (1967) a botanical classification is outlined and then followed by some general paleoecological conclusions (modified from Norris 1967, and Scagel et al. 1966).

DIVISION BRYOPHYTA

Musci

Sphagnidae

Family Sphagnaceae

Stereisporites antiquasporites
Aequitriradites spinulosus

DIVISION ARTHROPHYTA

Equisetales

Inaperturopollenites dubius (pars)

DIVISION LYCOPODOPHYTA

Lycopodiales

Lycopodiumsporites austroclavatidites
Lycopodiumsporites reticulumsporites
Lycopodiumsporites marginatus

Sestrosporites cf. S. pseudoalveolatus

Selaginellales

Acanthotriletes varispinosus

DIVISION PTEROPHYTA

Ficicales

Family Osmundaceae

Osmundacidites wellmanii

Baculatisporites cf. B. comaumensis

Family Schizaeaceae

Cicatricosisporites hallei

Cicatricosisporites hughesi

Cicatricosisporites perforatus

Appendicisporites tricornitatus

Appendicisporites potomacensis

Appendicisporites symskiensis

Appendicisporites unicus

Contignisporites cf. C. cooksoni

Contignisporites perplexus

Family Gleicheniaceae

Gleicheniidites apilobatus

Gleicheniidites senonicus

Family Cyatheaceae or Dicksoniaceae

Cyathidites minor

DIVISION PTERIDOSPERMOPHYTA -- INCERTAE SEDIS

Deltoidospora hallii

Deltoidospora psilostoma

Undulatisporites undulapolis

Pilosporites sp. Norris

Tigrisporites scurrandus

Taurocusporites segmentatus

Reticulisporites sp. Norris

Coronatispora valdensis

Camazonosporites insignis

?Cirratriradites teter
Laevigatosporites ovatus

DIVISION CYCADOPHYTA

Cycadeoideales or Bennettitales

Cycadopites fragilis

DIVISION CONIFEROPHYTA

Coniferales

Family Taxodiaceae

Inaperturopollenites dubius (pars)

Family Podocarpaceae

(species excluded from study)

Family Pinaceae

(species excluded from study)

DIVISION CONIFEROPHYTA -- INCERTAE SEDIS

Classopollis torosus
Circulina parva
Eucommiidites troedssonii

DIVISION GNETOPHYTA

Ephedrales

Equisetosporites staplinii
Equisetosporites sp. A

SPORES INCERTAE SEDIS

Schizosporis reticulatus

DIVISION ANTHOPHYTA

Monocotyledoneae -- Incertae sedis

Clavatipollenites hughesi
Clavatipollenites minutus

DICOTYLEDONEAE -- INCERTA SEDIS

Psilatricolpites psilatus
Tricolpites sagax
Tricolpites vulgaris
Tricolpites georgensis
Tricolpites prosimilis
Tricolpites paraneus

GENERAL PALEOECOLOGICAL INTERPRETATIONS

DIVISION BRYOPHYTA

Family Sphagnaceae - 2 genera and 2 species. Cosmopolitan. Species of this family are found in peat bogs, acid moors and on pond margins. They indicate wet lowland terrain. (Singh 1964, p. 32).

DIVISION ARTHROPHYTA

Equisetales - 1 genus and 1 species. Cosmopolitan except for Australia, with the most luxuriant species in the tropics. The plants grow well on acid soil and are often prolific on sand dunes, gravel bars and other suitable habitats are swamps, lake margins and moist woodlands. Although it generally is favored by moist climates and soils it tolerates somewhat xeric conditions.

DIVISION LYCOPODOPHYTA

Lycopodiales - 2 genera and 4 species. Cosmopolitan. Species are found chiefly in subtropical and tropical forests but also extend into arctic and temperate zones. They are not found in aric regions. (Sing 1964, p. 32).

Selaginellales - 1 genus and 1 species. Cosmopolitan. Most species are found in the wetter tropics in shades humid

spots, but some exist in temperate regions and a few are found in extreme climates such as the desert or the subarctic. In general they thrive in wet and shaded sites, but will tolerate exposed habitats such as rocky cliffs (Singh 1964, p. 32, Scagel et al. 1967, p. 380).

DIVISION PTEROPHYTA

Ficicales

Family Osmundaceae - 2 genera and 3 species. Cosmopolitan. Most species are temperate and tropical but various ones live in shaded moist woodlands (Sing 1964, p. 32).

Family Schizaeaceae - 3 genera and 9 species. Members of this family are mainly tropical and subtropical although some species of Schizea are found as far north as eastern Canada. (Singh 1964, p. 32).

Family Gleicheniaceae - 1 genus and 2 species. Species are mainly tropical but also extend into temperate regions (Singh 1964, p. 32).

Family Cyatheaceae or Dicksoniaceae - 1 genus and 1 species. The Cyatheaceae are mostly tree ferns and are confined largely to the tropics and subtropics, with some forms found in temperate regions, especially in the southern hemisphere. They occur mainly in humid forests. The Dicksoniaceae are tropical but a few are found in temperate regions also. The tree ferns of this family are tropical but several are species of ferns of the warm temperate southern hemisphere. (Singh, 1964, p. 32).

DIVISION PTERIDOSPERMOPHYTA -- INCERTAE SEDIS - 10 genera and
11 species. (Affinities are unknown).

DIVISION CYCADOPHYTA

Family Caytoniaceae - 1 genus and 1 species.

Cycadales or Bennettitales - 1 genus and 1 species. Cycadaceae occur exclusively in the tropics and subtropics in rocky, arid regions today but fossil evidence shows they were not so confined in the past (Singh 1964, p. 33).

DIVISION CONIFEROPHYTA

Coniferales - Family Podocarpaceae - Six of the seven genera of this family are restricted to relatively small regions of the southern hemisphere. Only the genus Podocarpus is widespread and ranges north of the equator in Central America, Africa and from Malaya to Japan.

Family Pinaceae - North America and Eurasia mostly on poorer soils and in cooler climates (Scagel et al. 1967, p. 513).

DIVISION CONIFEROPHYTA -- INCERTAE SEDIS - 3 genera and 3 species.

(Affinities are unknown).

DIVISION GNETOPHYTA

Ephedrales - 1 genus and 2 species. Species are mainly tropical to temperate, found in scattered patches in hot to very cold, arid, mountainous, rocky or desert regions (Singh 1964, p. 33).

DIVISION ANTHOPHYTA

Angiospermae - no safely recognizable modern analogues.

The largest group represented are Pterophyta, which is followed by Coniferophyta and then Anthophyta. These relationships are indicated in the lists above and also from the percentage composition of the assemblage shown on figures 7 and 8. Other elements represented are Pteridophyta and minor elements of the Bryophyta, Arthropophyta, Lycopodophyta, Cycadophyta and Ephedraceae. The assemblage is very similar to that described by Norris (1967) from the lower part of the Colorado Group of Alberta.

Most species listed have affinities to humid temperate and tropical modern species. Although there are many factors as outlined by Singh (1963, p. 68) that affect the relationship between vegetation and its pollen representation in sediments, the pollen-spore suite gives an indication of the paleofloral cover. If the law of uniformitarianism is applied conditions of the area during Ashville time may have been humid temperate to subtropical.

CHAPTER SIX - SUMMARY AND CONCLUSIONS

Sixty species belonging to thirty-eight genera of spores and pollen and seventy-one species of microplankton representing thirty-five genera were recovered from the lower part of the Ashville Formation of Saskatchewan. All samples contained spores, pollen and microplankton and indicate that deposition occurred in a marine environment with the shoreline at a distance such that spores and pollen are present but sporadic and few in number.

Based on the assemblage recovered, the strata are assigned to the late Albian stage. This age is based mainly on the spores and pollen recovered as it is felt that any attempt to refine the age to this level on the basis of dinoflagellates would be premature.

The lower part of the Ashville Formation appears to be biostratigraphically correlative with the Joli Fou and Viking Formations and the overlying shale unit below the Fish Scale Zone of the lower part of the Colorado Group in Alberta.

It appears that the base of the Ashville at the locations studied is younger than the base of the Joli Fou.

In the United States part of the Patapsco Formation of Maryland and part of the "Comanche Series" of Oklahoma is correlative. Dinoflagellates indicate some degree of correlation with the upper Greensand of England and the Albian of Rumania.

The microplankton assemblage from the Alwinal Sarcee drill-hole and below 1134 feet in the Southwest Potash Bredenbury drill-hole is interpreted as reflecting normal marine conditions of the Lower Colorado sea.

At 1134 feet the assemblage of the Bredenbury sequence changes, reflecting what may be a change to more restricted marine conditions in the sea.

The absence of this assemblage in the Sarcee drill-hole may be due to erosion and/or non deposition and this may be at least be part of the reason for the difference in thickness in the two drill-holes.

The spore and pollen suite reflects a warm humid temperate to subtropical land flora composed predominantly of ferns, conifers and angiosperms with minor cycadalean, ephedralean, equisetalean, lycopodalean and bryophytic elements.

CHAPTER SEVEN - FORMAL TAXONOMIC DESCRIPTIONS

Introduction: All of the specimens illustrated in this thesis come from either the Southwest Potash Bredenbury well Lsd. 11, Sec. 36, Tp. 22, R. 1, W. 2nd Mer. or the Alwinsal Sarcee well Lsd. 4, Sec. 28, Tp. 33, R. 23, W. 2nd Mer. from the lower part of the Ashville Formation above the Swan River Group and below the base of the Fish Scale Zone within the Ashville Formation. The code designation for Alwinsal slides is "A" while the code designation for Southwest Potash slides is "S". The reader is referred to Appendix I for details of specimen locations in the slides. Appendix I also contains a summary of preparation and study techniques and appendix II consists of a summary lithologic description.

Species represented by letters, for example A or B, may represent new species. However due to the small number of each species recovered new species names have not been assigned at this time.

Class DINOPHYCEAE Pascher

Subclass DINIFEROPHYCIDAE Bergh

Cyst - Family GONYAULACYSTACEAE Sarjeant and Downie 1966

Genus GONYAULACYSTA Deflandre ex Norris and Sarjeant 1965 emend.
Sarjeant 1969

TYPE SPECIES: Gonyaulacysta jurassica (Deflandre 1964)
(=Gonyaulax jurassica Deflandre 1938).

REMARKS: Sarjeant emended the generic diagnosis to include reference to tabulation and to exclude forms characterized by very long sutural spines, or a general spine cover.

Note on the term hystrichospheres

The general term in use for spiniferous fossil phytoplanktonic cysts is hystrichospheres. This is derived from Hystrichosphaera Wetzel 1933* a name for a fossil form. This is a junior synonym of the term Spiniferites Mantell 1850 (Loeblich and Loeblich 1966). Wall and Dale (1970) and others have indicated that the modern dinoflagellate genus Gonyaulax gives rise to a Hystrichosphaera or hystrichosphaerid cysts. The fossil cysts of Gonyaulax design are named Gonyaulacysta Deflandre ex Norris and Sarjeant 1965. This taxonomic conundrum will have to be handled by the Commission of the International Code of Botanical Nomenclature as there is a direct conflict between the terms governing the paleobotanical and the modern groups. Wall and Dale (1968) suggest that modern names take precedence. Likewise the artificial cyst-families fall somewhat outside the code and the commission will have to deal with this as well, ultimately.

Until the commission rules on these matters (supra) the term Hystrichosphaera is retained for this work as well as the name Gonyaulacysta and the terms applied to higher or derived taxa such as Gonyaulacystaceae and Hystrichosphaeraceae. R. Harland (pers. comm.) suggests that the modern dinoflagellate cysts be named according to their natural affinities and that fossil dinoflagellate cysts (pre-Quaternary) be named according to the form genus concept.

* Wetzel, O. (1933): Die in organischer Substanz erhaltenen Mikrofossilien des baltischen Kreidefeurersteins mit einem sedimentpetrographischen und stratigraphischen anhang; Palaeontographica, Vol. 77 and 78; Pt. A, pp. 47-156.

Gonyaulacysta whitei Sarjeant 1966a

Plate I, Figure 3.

1966a Gonyaulacysta whitei Sarjeant, p. 126 - 127, pl. 14, fig. 2.

DESCRIPTION: Body outline ovoidal; hypotract rounded; epitract rounded extending into an apical horn; plate boundaries marked by very fine membraneous crests, densely and finely perforate with ragged edges; cingulum broad, ca. 8 microns wide, forming a strong leavorotatory spiral; sulcus sigmoidal extending onto the epitract and hypotract; body surface finely granulate; wall very thin.

REMARKS: No archeopyle was observed; crests bordering the antapex are indistinct and strong broad spines supporting crests that border the antapex, mentioned by Sarjeant, have not been observed on these specimens. As the original type species description is based on only one specimen, it is felt that these differences may lie within the variation encompassed by the species.

SIZE RANGE: Length 60 to 67 microns; width 47 microns; apical horn ca. 8 microns. Number of specimens measured, 2.

PREVIOUS RECORDS: Cenomanian of England (Sarjeant 1966a).

LOCALITY OF FIGURED SPECIMENS: Pl. I, Fig. 3: S/5/3 8/99 Southwest Potash well; depth 1253-1258 feet.

Genus CRIBROPERIDINIUM Neale and Sarjeant emend. Davey 1969.

TYPE SPECIES: Cribroperidinium septimum Neale and Sarjeant 1962

REMARKS: Cribroperidinium is basically a form of Gonyaulacysta which possesses additional crests. Tabulation for the genus is ? 6', (1-5a), 8-9", Oc, 9"', Ip, 1-3 p.c.), 0''' (-? 2'''). By removal of

the crests Davey found a normal "Gonyaulax" type pattern of tabulation could be reconstructed. It is felt more investigation is necessary to establish whether the position of the crests is stable enough to warrant the designation of Cribroperidinium as a genus separate from Gonyaulacysta.

Cribroperidinium intricatum Davey 1969

1969 Cribroperidinium intricatum Davey, p. 125, pl. 2, figs. 1-3. Plate I, Figures 5,6,8.

DESCRIPTION: Body outline oval; epitract and hypotract approximately equal; apical horn subconical, often slightly curved; body wall 1 to 1.5 microns thick, densely granular; crests low thickenings 2 - 3 microns wide in the antapical region and sometimes in other areas forming membranous, thin, perforate flanges up to 15 microns high; tabulation is somewhat variable but accords with that of the genus; cingulum narrow, 4 - 6 microns wide laevorotatory; sulcus mostly developed on the hypotract but extends a short distance onto the epitract, it is wider and larger on the hypotract.

REMARKS: Ornamentation on the plate areas appears to be quite variable.

SIZE RANGE: Length 133 (145) 157 microns; width 94 (112) 124 microns; length of apical horn ca. 40 microns. Number of specimens measured, 5.

PREVIOUS RECORDS: Rare in British Albian and Cenomanian sediments (Davey 1969);,recorded from Albian strata of Saskatchewan (Davey 1969); ranges from Albian to Lower Cenomanian (Davey 1969).

LOCALITY OF FIGURED SPECIMENS: Pl. I, Fig. 5: S/27/3 12/96
 Southwest Potash well; depth 1134-1139 feet. Pl. I, Fig. 8: S/43/3
 20.5/99 Southwest Potash well; depth 1040-1045 feet. Pl. I, Fig. 6:
 S/14/3 9/108 Southwest Potash well; depth 1203-1208 feet.

Cribroperidinium cf. C. muderongensis (Cookson and Eisenack)
 Sarjeant 1966a.

Plate I, Figures 4, 11.

DESCRIPTION: Body outline suboval to biconical with a long slender tapering apical horn capped with a small "lid-like" closing platelet; body wall thick, perforate to granular, ornamented with numerous short blunt spines or granules, tabulation variable but conforms to the genus; sutures thick 1.5-2 microns wide, raised, often ornamented with low broad, cone-like projections; crests well developed, up to 10 to 12 microns high, thin granular to finely perforate membrane; cingulum laevorotatory, ca. 10 microns wide; precingular archeopyle.

REMARKS: Gonyaulacysta perforans (Cookson and Eisenack) Sarjeant 1966a is similar but has a thin, smooth body surface. Gonyaulacysta scotti (Cookson and Eisenack) Sarjeant 1966a differs in having spiny outgrowths that are usually fused, forming a delicate membrane and it is slightly smaller. The Ashville specimens are slightly larger than Cribroperidinium muderongensis (Cookson and Eisenack) Davey 1969.

PREVIOUS RECORDS: Aptian of Western Australia (Cookson and Eisenack 1958).

LOCALITY OF FIGURED SPECIMENS: Pl. I, Fig. 11: S/43/3 12/98
 Southwest Potash well; depth 1040-1045 feet. Pl. I, Fig. 4: S/43/3

12.5/103 Southwest Potash well; depth 1040-1045 feet.

Cribroperidinium cf. C. orthoceras Eisenack emend.
Sarjeant 1966a

Plate I, Figures 2,7.

DESCRIPTION: Body outline ovoidal; hypotract rounded; epittract of similar size extending into a tapering apical horn; cingulum laevorotatory; sulcus present on hypotract extending onto epittract; plate areas indistinct due to densely granular surface; large precingular archeopyle.

SIZE RANGE: Length 78 (90) 92 microns; width 51 (60) 66 microns.
Number of specimens measured, 8.

PREVIOUS RECORDS: C. orthoceras (Eisenack 1958) is an abundant and characteristic species of the Cretaceous of Europe having a known range from upper Valanginian to Turonian.

LOCALITY OF FIGURE SPECIMENS: Pl. I, Fig. 7: A/10/2 18/105
Alwinsal well; depth 1378-1383 feet. Pl. I, Fig. 2: A/10/3 5.5/113
Alwinsal well; depth 1378-1383 feet.

?Cribroperidinium sp. A

Plate II, Figures 1,7.

DESCRIPTION: Body outline ovoidal; hypotract rounded; epittract extending into a broadly based stout, tapering, apical horn; cingulum indistinct; body surface coarsely granular making tabulation indistinguishable; archeopyle precingular.

SIZE RANGE: Length 148 - 157 microns; width 103 - 112 microns;
apical horn 20 - 28 microns. Number of specimens measured, 3.

LOCALITY OF FIGURED SPECIMENS: Pl. II, Fig. 1: S/14/3 6/97
 Southwest Potash well; depth 1203-1208 feet. Pl. II, Fig. 7: S/14/2
 10/100 Southwest Potash well; depth 1203-1208 feet.

?Cribroperidinium sp. B

Plate II, Figures 5,8.

DESCRIPTION: Body outline elongated, ovoidal; hypotract rounded; epitract larger, tapering towards apex; a sharply delimited apical horn; cingulum strongly spiral; body surface coarsely granular.

REMARKS: This species is smaller than Cribroperidinium sp. A and is less robust; the apical horn is more sharply delimited also. Although tabulation of the above two species cannot be determined completely it resembles that of Cribroperidinium so they have been to this genus.

SIZE RANGE: Length 103 - 120 microns; width 79 - 87 microns; length of apical horn 14 - 15 microns. Number of specimens measured, 2.

LOCALITY OF FIGURED SPECIMEN: Pl. II, Fig. 8: S/8/3 6.5/103
 Southwest Potash well; depth 1235-1240 feet. Pl. II, Fig. 5: S/19/2
 16/108 Southwest Potash well; depth 1181-1186 feet.

Genus LEPTODINIUM Klement 1960 emend. Davey et al. 1969

TYPE SPECIES: Leptodinium subtile Klement 1960.

REMARKS: The reflected tabulation of this genus is 3-4', 0-1a, 6", 6c, 5-6"', Ip, 0-1 p.v., I"', 0-x s. It lacks apical median and antapical horns, Sutures are typically marked by ridges or low crests without spines or denticles. Archeopyle precingular, formed by the loss of a single plate, 3".

Leptodinium cf. L. eumorphum (Cookson and Eisenack) Eisenack 1961

Plate I, Figure 1.

DESCRIPTION: Body large, ovoidal; epitract broadly rounded; hypotract rounded, narrowing toward the antapex; cingulum helicoidal; plates bordered by thin membranes; body surface granulate to "vermiculate"; antapex ornamented by a high membraneous ridges bordering the plates cingulum also bordered by similar membrane.

REMARKS: Tabulation is similar to that for Gonyaulacysta eumorpha (Cookson and Eisenack) Sarjeant 1962 but is not identical; G. eumorpha is considerably smaller and Cookson and Eisenack don't mention any surface ornamentation on their specimens which differs from the distinct sculpture on these specimens.

SIZE RANGE: Overall length 82 microns; width 64 microns; body length 70 microns. Number of specimens measured, 1.

PREVIOUS RECORDS: L. eumorphum has been recorded from Oxfordian to Lower Kimmeridgian and probable Tithonian strata of Western Australia (Cookson and Eisenack 1960) and from the (Upper Jurassic) Ampthill Clay of England.

LOCALITY OF FIGURED SPECIMEN: Pl. I, Fig.1: S/27/1 11/97

Southwest Potash well; depth 1134-1139 feet.

Leptodinium delicatum (Davey) Sarjeant et al. 1969

Plate I, Figure 10.

1969 Gonyaulacysta delicata Davey, p. 123, pl. 1, figs. 7,8.

DESCRIPTION: Body outline subspherical; body wall thin, less than 0.5 microns, no apical horn, small circular plate in this position; body wall thin and smooth.

REMARKS: Due to the extremely thin nature of the body wall most specimens are distorted and bent, thus tabulation cannot be determined easily.

SIZE RANGE: Length 55 (61) 63 microns; width 51 (57) 64 microns.
Number of specimens measured, 8.

PREVIOUS RECORDS: Recorded from the Lower Colorado Group of Saskatchewan (Cenomanian) by Davey (1969).

LOCALITY OF FIGURED SPECIMENS: Pl. 1, Fig. 10: S/14/3 14/104
Southwest Potash well; depth 1203-1208 feet.

Cyst - Family PAREODINIACEAE Gocht emend. Sarjeant and Downie 1966

Genus PAREODINIA Deflandre 1947

TYPE SPECIES: Pareodinia ceratophora Deflandre 1947.

Pareodinia sp. A

Plate I, Figure 9.

DESCRIPTION: Body outline subovate, flask-shaped, apical end extending into a slender slightly curved apical horn; antapex rounded; no tabulation or cingulum apparent; surface of body faintly granulate and possessing a very thin membraneous cover; archeopyle

apparently precingular.

REMARKS: Pareodinia ceratophora Deflandre 1947 is similar but is smaller in all occurrences to date. Pareodinia aphelia Cookson and Eisenack 1958 is similar in appearance but does not possess a membraneous cover. No archeopyle has been noted.

SIZE RANGE: Length 89 (96) 102 microns; width 43 (51) 59 microns. Number of speimens measured, 2.

LOCALITY OF FIGURED SPECIMENS: Pl. 1, Fig. 9: S/27/3 17/106 Southwest Potash well; depth 1134-1139 feet.

Genus APTEODINIUM Eisenack 1958

TYPE SPECIES: Apteodinium granulatum Eisenack 1958.

Apteodinium granulatum Eisenack 1958

Plate II, Figures 9,15.

1958 Apteodinium granulatum Eisenack, p. 386, pl. 23, fig. 8 to 14.

DESCRIPTION: Body outline ovoidal; hypotract and epittract about equal in size, separated by a circular clearly defined cingulum; epittract extends into a short blunt apical horn; archeopyle large, apparently precingular in position; body surface densely and coarsely granular such that no tabulation is apparent.

REMARKS: Ashville specimens are longer than the type material which has a range in length of 50 to 80 microns and the range of breadth listed is 50 to 67 microns.

SIZE RANGE: Length 60 (77) 99 microns; breadth 52 (62 80 microns; apical horn ca. 7 microns. Number of specimens measured, 7.

PREVIOUS RECORD: Upper Hauterivian, upper Baremian and Aptian sediments of Germany (Eisenack 1958).

LOCALITY OF FIGURED SPECIMENS: Pl. II, Fig. 9: S/22/2

12.5/101.5 Southwest Potash well; depth 1160-1165 feet. Pl. II, Fig. 15:

S/20/2 10/106 Southwest Potash well; depth 1170-1175 feet.

Genus SPINIDINIUM Cookson and Eisenack 1962b

TYPE SPECIES: Spinidinium stylonifera (Cookson and Eisenack 1962. (1962b)

REMARKS: Stanley (1965) noted that the original description of Cookson and Eisenack (1962b) is vague. No mention is made of how Spinidinium differs from Deflandrea or Wetzeliella. Stanley noted that Deflandrea usually has a smooth outer body wall which differs from that of Spinidinium which is ornamented with spines. He noted also that Spinidinium appears to differ from Wetzeliella in lacking the characteristic rhombohedral shape of that genus.

Spinidinium microceratium Stanley 1965

Plate II, Figure 6.

1965 Spinidinium microceratium Stanley, p. 227, pl. 22, figs. 5-6.

DESCRIPTION: Body outline subovoidal; epittract larger than hypottract; apical horn short; antapical horns unequally developed, small and short; membrane of outer body thin and folded; cingulum distinct, bordered on top and bottom by rows of short spines; cingulum free of spines; longitudinal furrow wide, extending from the cingulum to antapical horns; body surface granular, ornamented by irregularly spaced short spine-like appendages; tabulation present but indistinct; archeopyle intercalary. Inner body thin walled; almost fills the outer body.

REMARKS: This species does not conform totally to the genus diagnosis for Spinidinium because it has two antapical horns. This form appears to be transitional between the genus Spinidinium and the genus Deflandrea. It cannot be placed in Deflandrea at present because that genus diagnosis excludes forms ornamented with spines.

The only notable differences between Spinidinium and Deflandrea is the presence of spines ornamenting Spinidinium as opposed to the smooth, slightly granular outer surface of Deflandrea and the presence of one antapical horn for Spinidinium as opposed to two for Deflandrea.

At present it would appear that ornamentation is the only criterion separating Spinidinium microceratium Stanley 1965 from Deflandrea and as ornamentation is usually considered a specific criterion, the generic diagnosis of Deflandrea might be emended to include spinose forms.

It is interesting to note that Wilson (1967) has assigned spine bearing forms with two antapical horns to the genus Deflandrea. This at present violates the generic diagnosis for Deflandrea but it would seem to indicate he would favor such an emendation.

SIZE RANGE: Length 51 (58) 66 microns; width 37 (42) 49 microns.
Number of specimens measured, 14.

PREVIOUS RECORDS: Stanley (1965) reported Spinidinium microceratium from the Paleocene of South Dakota.

LOCALITY OF FIGURED SPECIMEN: Pl. II, Fig. 6: S/1/1 6/105
Southwest Potash well; depth 1278-1283 feet.

Genus TRICHODINIUM Eisenack and Cookson emend.

Clarke and Verdier 1967

TYPE SPECIES: Trichodinium pellitum Eisenack and Cookson 1960.

REMARKS: Clarke and Verdier (1967, p. 18) have emended the generic diagnosis in order to group under the same generic name all forms which have a precingular archeopyle, a distinctive sculpture consisting of short hairs, spines or flat topped processes, and a small apical horn formed by coalescence of hairs or bristles in the apical region.

Trichodinium cf. T. hirsutum Cookson 1965b

Plate II, Figures 10,11,14.

DESCRIPTION: Body outline ovoid, with a short branched apical projection; antapical end rounded with a fan shaped antapical projection; faint indication of an indistinct equatorial cingulum; precingular archeopyle; body membrane ornamented with solid, simple or branched pointed short hair-like processes, processes longest and most numerous along the margins especially in the region of the girdle, short and in small groups on the dorsal surface, on the ventral surface processes very small and sparse; longitudinal furrow indistinct; body membrane of dorsal surface marked into irregularly shaped areas by ridges and the confluence of appendage bases, several often running together to form raised thickenings.

REMARKS: Specimens from the lower part of the Ashville Formation are smaller than those described by Cookson (1965b) and the equatorial girdle does not appear to be as distinct.

Trichodinium intermedium Cookson and Eisenack 1960 differs from this species having no antapical projection, and in its shorter, finer appendages.

SIZE RANGE: Overall length 69 (80) 84 microns; width 60 (74) 79 microns; processes up to 11 microns long. Number of specimens measured, 14.

PREVIOUS RECORDS: Trichodinium hirsutum has been recorded from the Paleocene of Australia (Cookson 1965b).

LOCALITY OF FIGURED SPECIMENS: Pl. II, Fig. 14: S/27/1 18.5/98.5 Southwest Potash well; depth 1134-1139 feet. Pl. II, Fig. 11: S/27/3 16.5/93 Southwest Potash well; depth 1134-1139 feet. Pl. II, Fig. 10: S/1/1 18.5/97.5 Southwest Potash well; depth 1278-1283 feet.

Cyst-Family FROMEACEAE Sarjeant and Downie 1966

Genus FROMEA Cookson and Eisenack 1958

TYPE SPECIES: Fromea amphora Cookson and Eisenack 1958.

Fromea amphora Cookson and Eisenack 1958

Plate II, Figure 16.

1958 Fromea amphora Cookson and Eisenack, p. 56, pl. 5, figs. 10,11.

DESCRIPTION: Body outline ellipsoidal; a distinct narrow equatorial girdle; apical portion detaches forming an apical archeopyle; body wall relatively thick, surface laevigate, no trace of tabulation.

REMARKS: Specimens from the Ashville closely resemble those figured by Cookson and Hughes (1964) from the upper Gault, Greensand and Chalk Marl of Britain.

SIZE RANGE: Length 77 (93) 107 microns; width 58 (68) 74 microns.

Number of specimens measured, 9.

PREVIOUS RECORDS: The presently known range in Australia is from Aptian to Cenomanian (Cookson and Hughes 1964); Aptian to Cenomanian of Western Australia (Cookson and Eisenack 1958); Barremian of Germany (Alberti 1961) and the upper Gault, Greensand and Chalk Marl of Britain (Cookson and Hughes 1964; Davey 1969).

LOCALITY OF FIGURED SPECIMEN: Pl. II, Fig.16: S/6/1 14/108 Southwest Potash well; depth 1249-1253 feet.

?Fromea sp. A

Plate II, Figure 17.

DESCRIPTION: Body outline sac-like; body characteristically folded transversely along a line presumably in the position of the equatorial girdle; two folds characteristically extend from the girdle obliquely converging towards the apical end and extend obliquely from the girdle to the antapical end sometimes crossing just before reaching the antapex; apical portion detaches to form what appears to be an apical archeopyle; body wall thin and faintly granulate.

REMARKS: Fromea amphora Cookson and Eisenack 1958 differs from this form in not possessing folds and in having a more distinct cingulum. Its body wall is also thicker. The transverse fold is interpreted as an equatorial cingulum; otherwise these specimens resemble the genus Paleostomatocystis.

SIZE RANGE: Length 66 (99) 103 microns; width 40 (49) 69 microns.

Number of specimens measured, 11.

LOCALITY OF FIGURED SPECIMEN: Pl. II, Fig. 17: S/16/3

13.5/101.5 Southwest Potash well; depth 1249-1253 feet.

Genus TENUA Eisenack 1958

TYPE SPECIES: Tenua hystrix Eisenack 1958.

Tenua sp. A

Plate II, Figure 13.

DESCRIPTION: Body outline subcircular, apical portion detaches forming an apical archeopyle; antapex rounded; surface granulate, ornamented with short stiff spine-like appendages; no indication of cingulum or tabulation.

REMARKS: No complete specimens have been observed; it appears that opening occurs by detachment of the apex along a zig - zag line of dehiscence. Cyclonephelium sp. Baltes 1967 is similar but differs mainly in being slightly larger and in the primarily peripheral distribution of processes. This specimen is placed in the genus Tenua because there is no indication of processes being restricted to the margins of the body.

SIZE RANGE: Length 69 (71) 79 microns; width 51 (56) 64 microns.
Number of specimens measured, 3.

LOCALITY OF FIGURED SPECIMEN: Pl. II, Fig. 13: S/6/2 7.5/101.5
Southwest Potash well; depth 1249-1253 feet.

Cyst-Family CANNINGIACEAE Sarjeant and Downie 1966a

Genus CANNINGIA Cookson and Eisenack 1960b

TYPE SPECIES: Canningia reticulata Cookson and Eisenack 1960.
(1960b)

Canningia colliveri Cookson and Eisenack 1960b

Plate II, Figure 2.

For synonymy see Clarke and Verdier (1967, p. 20).

DESCRIPTION: Body outline pentagonal, widest at the equator; antapex with two antapical projections, unequal, one very short and blunt, the other more conical and longer; apical portion detaches forming an apical archeopyle with a zig-zag margin; body wall thin, faintly granulate to sparsely spinose; no tabulation apparent except for an indication that post-cingular plates are present due to small slits at the edge of the archeopyle.

SIZE RANGE: Length without apical portion 78 (88) 97 microns; width 71 (83) 94 microns. Number of specimens measured, 1.

PREVIOUS RECORDS: Aptian of Australia (Cookson and Eisenack 1960b; Eisenack and Cookson 1960; Turonian on the Isle of Wight (Clarke and Verdier 1967); Aptian to middle Albian of the Mannville Group of Alberta (Singh 1964).

LOCALITY OF FIGURED SPECIMEN: Pl. II, Fig. 2: S/43/2 11/99.5 Southwest Potash well; 1040-1045 feet.

Canningia cf. C. reticulata Cookson and Eisenack 1960b

Plate II, Figure 12.

DESCRIPTION: Body outline roughly pentagonal with straight to convex sides; hypotract with two unequally developed antapical projections with an intervening basal indentation; cingulum faintly denoted by a less densely ornamented area slightly above the equator; shell membrane densely ornamented by a fine reticulum, thick walled, no tabulation apparent but plates indicated by the zig-zag margin of the apical archeopyle.

REMARKS: This specimen is smaller than Australian forms that range from 94 - 108 microns X 74 - 98 microns.

SIZE RANGE: Length (without apical portion) 62 microns; width 66 microns. Number of specimens measured, 1.

PREVIOUS RECORDS: Canningia reticulata has been found in sediments of probable Turonian age in Australia (Cookson and Eisenack 1960b); Cenomanian on the Isle of Wight (Clarke and Verdier 1967).

LOCALITY OF FIGURED SPECIMEN: Pl. II, Fig. 12: S/10/1 11/105 Southwest Potash well; depth 1225-1230 feet.

Genus BROOMEA Cookson and Eisenack 1958

TYPE SPECIES: Broomea ramosa Cookson and Eisenack 1958.

Broomea jaegeri Alberti 1961

Plate II, Figures 3,4.

1961 Broomea jaegeri Alberti, p. 26, pl. 5, figs. 1-7.

1962 Pseudoceratium gochti Pocock, p. 79, pl. 14, figs. 213-214.

1964 Pseudoceratium gochti Pocock in Singh, p. 145, pl. 20, fig. 7.

DESCRIPTION: Body outline roughly ellipsoidal, longer than broad; apex prolonged into a long slender apical horn; antapex rounded with two short pointed antapical horns of unequal length, one about one half as long as the other; no cingulum or longitudinal furrow developed; body wall thin, granulate; archeopyle apical.

REMARKS: A polygonal plate-like area outlined by small fissures occurs in the body wall of the apical portion of the body in some specimens. This feature is comparable to ones present on the figures of Alberti (1961) and probably indicates presence of tabulation. No other evidence of tabulation is present. Another feature is a small circular area in the hypotract where the body wall is very thin; the function or significance of this feature is not known. These specimens extend to known length range.

SIZE RANGE: Overall length 83 (133) 180 microns; width 30 (35) 37 microns; apical horn up to 77 microns. Number of specimens measured, 4.

PREVIOUS RECORDS: Lower and Upper Cretaceous of western Canada (Pocock 1962); Lower Cretaceous of Alberta (Singh 1964); upper Barremian of Germany (Alberti 1961).

LOCALITY OF FIGURED SPECIMENS: Pl. II, Fig. 3: S/43/3 11/98.5 Southwest Potash well; depth 1040-1045 feet. Pl. II, Fig. 4: S/14/3 14.5/98 Southwest Potash well; depth 1203-1208 feet.

Cyst-Family HYSTRICHOSPHAERIDIACEAE Evitt emend.
Sarjeant and Downie 1966

Genus HYSTRICHOSPHAERIDIUM Deflandre emend. Davey and Williams 1966b

TYPE SPECIES: Hystrichosphaeridium tubiferum (Ehrenberg)

Deflandre 1937 (= Xanthidium tubiferum Ehrenberg 1938).

REMARKS: Davey and Williams (1966b) have emended the generic diagnosis to include subspherical chorate cysts possessing a reflected tabulation of 4' (-5'), 6", 6c, 5-6"', 1p, 1''' and a variable number of sulcal processes. The processes are hollow, open distally, intratabular and there is generally only one process per plate area. The number of processes rarely exceeds 30. The archeopyle is apical.

Hystrichosphaeridium possesses 6 cingular processes in contrast to Oligosphaeridium which has none.

Hystrichosphaeridium salpingophorum (Deflandre) emend.

Davey and Williams 1966b.

Plate III, Figures 1,2.

For synonymy see Davey and Williams (1966b, p. 61).

DESCRIPTION: Central body subspherical with numerous processes; processes tubiform or expanding slightly distally, distal margins denticulate; granular endophragm and smooth periphragm.

REMARKS: H. salpingophorum (Davey and Williams 1966b) is slightly larger than these specimens.

SIZE RANGE: Diameter of body 30 (34) 37 microns; length of processes 13 - 17 microns.

PREVIOUS RECORDS: Reported from the Eocene London Clay (Davey and Williams 1966b); and Senonian of France (Deflandre 1936b).

LOCALITY OF FIGURED SPECIMENS: Pl. III, Fig. 1: S/16/2 9/95.5 Southwest Potash well; depth 1196-1198 feet. Pl. II, Fig. 2: S/27/3 12/96 Southwest Potash well; depth 1134-1139 feet.

Hystrichosphaeridium stellatum Maier 1959

Plate III, Figures 3,4.

For synonymy see Clarke and Verdier (1967, p. 55).

DESCRIPTION: Central body ovoidal to subsphaerical; wall smooth, bearing about 18 cylindrical tubular processes that flare distally, margins of processes aculeate to denticulate, one larger antapical process with a fenstrate distal margin.

SIZE RANGE: Diameter of body 34-36 microns; length of processes up to ca. 18 microns. Number of specimens measured, 4.

PREVIOUS RECORDS: Hauterivian of northern Germany (Gocht 1959). Albian of Rumania (Baltes 1967), Albian to Cenomanian of Australia (Cookson and Eisenack 1962a), upper Albian to lower Cenomanian of England (Cookson and Hughes 1964), middle Oligocene and middle Miocene of northwestern Germany (Maier 1959).

LOCALITY OF FIGURED SPECIMENS: Pl. III, Fig. 3: A/17/1 20/108 Alwinsal well; depth 1338-1343 feet. Pl. III, Fig. 4: S/14/2 7/97 Southwest Potash well; depth 1203-1208 feet.

Genus CLEISTOSPHAERIDIUM Davey, Downie, Sarjeant and Williams
1966

TYPE SPECIES: Cleistosphaeridium diversispinosum Davey et al.
1966.

?Cleistosphaeridium aciculare Davey 1969

Plate III, Figure 5.

1969 ?Cleistosphaeridium aciculare Davey, p. 158, pl. 6, figs. 11, 12.

DESCRIPTION: Central body subspherical to oval; wall densely granular bearing numerous fine acuminate spines, less than one third of shell diameter in length; no tabulation or cingulum is apparent;

no archeopyle observed.

REMARKS: No archeopyle has been observed in specimens of this study and none was observed by Davey (1969).

SIZE RANGE: Diameter of central body 45 (54) 80 microns, length of processes ca. 8 microns. Number of specimens measured, 4.

PREVIOUS RECORDS: Recorded from Albian and Cenomanian strata of the Colorado Group of Saskatchewan by Davey (1969).

LOCALITY OF FIGURED SPECIMEN: Pl. III, Fig. 5: A/13/3 13/108.5 Alwinal well; depth 1363-1368 feet.

Cleistosphaeridium polypes (Cookson and Eisenack) Davey 1969

Plate III, Figure 9.

For synonymy see Davey (1969, p. 154).

DESCRIPTION: Central body spherical to subspherical with more than 50 smooth hollow appendages which taper distally but remain open; in the distal 1/4 to 1/3 of their length occurs a whorl of small closed pointed processes; body surface granular, no indication of tabulation, cingulum or archeopyle.

REMARKS: Cleistosphaeridium polypes (Cookson and Eisenack) Davey resembles Cordosphaeridium erectum (Manum and Cookson) Davey and Williams but according to Manum and Cookson (1964), C. erectum has more processes; the processes are shorter, wider and the ends are considerably longer and branch more than those of Hystrichosphaeridium recurvatum subsp. polypes (Cookson and Eisenack 1962a). The processes of C. erectum are more upright and do not have such a recurving tendency as Cleistosphaeridium polypes. The overall diameter of these species ranges slightly lower than those of Cookson and Eisenack (1962a).

SIZE RANGE: Overall diameter 47 (73) 94 microns; diameter of central body 38 (46) 56 microns; length of processes up to 17 microns. Number of specimens measured, 9.

PREVIOUS RECORDS: Aptian to ? Cenomanian of Australia (Cookson and Eisenack 1962a), middle and upper Cenomanian of England, (Cenomanian) Woodbine of Texas and Cenomanian strata of Saskatchewan Davey 1969).

LOCALITY OF FIGURED SPECIMEN: Pl. III, Fig. 9: S/25/1 13/104 Southwest Potash well; depth 1144-1149 feet.

Cleistosphaeridium sp. A

Plate III, Figures 6,7.

DESCRIPTION: Body outline ellipsoidal to suboval; thin smooth endophragm and thin smooth periphragm which forms the processes; processes hollow, tapering, patulate, masking any indication of tabulation; archeopyle apparently apical.

REMARKS: These specimens resemble Cleistosphaeridium polypes (Cookson and Eisenack) Davey 1969, but the outline of the body is typically more ellipsoidal compared to the circular to subcircular body of C. polypes.

SIZE RANGE: Length of body 64-72 microns; breadth of body 40-44 microns; length of processes ca. 16 microns. Number of specimens measured, 2.

LOCALITY OF FIGURED SPECIMENS: Pl. III, Fig. 7: S/1/3 10/105 Southwest Potash well; depth 1278-1283 feet. Pl. III, Fig. 6: S/5/3 19.5/106 Southwest Potash well; depth 1253-1258 feet.

Cleistosphaeridium sp. B

Plate III, Figures 8, 12.

DESCRIPTION: Body outline ovoidal to subvoidal; wall thin, smooth, bearing numerous long, fine spines, spines closed and pointed distally; archeopyle apical; no tabulation apparent.

REMARKS: Specimens resemble ?Cleistosphaeridium parvum Davey 1969 but are much larger.

SIZE RANGE: Overall diameter 41 (66) 86 microns; diameter of central body 37 (46) 56 microns.

LOCALITY OF FIGURED SPECIMENS: Pl. III, Fig. 8: S/5/1 12/96.5 Southwest Potash well; depth 1253-1258 feet. Pl. III, Fig. 12: S/28/3 6/107 Southwest Potash well; depth 1129-1134 feet.

Genus CORDOSPHAERIDIUM Eisenack emend. Davey and Williams 1966b

TYPE SPECIES: Cordosphaeridium inodes (Klumpp) Eisenack 1963
(=Hystrichosphaeridium inodes Klumpp 1953).

REMARKS: Cordosphaeridium differs from related genera in the form of the archeopyle which has the shape of a convex triangle with rounded corners.

The genus was proposed by Eisenack (1963) for forms possessing characteristically fibrous processes. Davey and Williams (1966b) consider tabulation a more diagnostic feature for generic diagnosis than fibrosity of the processes which is very variable within the genus.

The reflected tabulation for the genus is 1', 6'', 6c, 6''', (1p), 1'''' and a variable number of sulcal processes.

Cordosphaeridium cf. C. inodes (Klumpp) Eisenack 1963

Plate III, Figures 10,11.

DESCRIPTION: Body outline subspherical; body wall fibrous bearing short fibrous processes; processes buccinate, hollow, open distally; tabulation not apparent; no cingulum indicated; archeopyle with the shape of a convex triangle, probably precingular.

SIZE RANGE: Diameter of body 34 (36) 39 microns; length of processes up to 9 microns. Number of specimens measured, 5.

PREVIOUS RECORDS: Cordosphaeridium inodes (Klumpp) Eisenack 1963 has been recorded from the (Eocene) London Clay (Davey and Williams 1966b) and from the Isle of Wight in sediments ranging in age from lower Eocene to middle Miocene; recorded from the Eocene of Germany (Klumpp 1953).

LOCALITY OF FIGURED SPECIMENS: Pl. III, Fig. 10: S/23/2 13/110.5 Southwest Potash well; depth 1155-1160 feet. Pl. III, Fig.11: A/18/1 8.5/110 Alwinal well; depth 1333-1338 feet.

Cordosphaeridium cf. C. multispinosum Davey and Williams 1966b

Plate III, Figure 13.

DESCRIPTION: Body outline subspherical to ovoidal; endophragm fibrous with many, often fibrous, processes; processes tapering, open or closed distally, some branching distally, some fine, acuminate; processes arranged in rows with tabulation typical of the genus; appear to be 2 processes per plate area and sometimes 3; apical archeopyle with an uninterrupted margin.

REMARKS: C. multispinosum Davey and Williams 1966b has more than 45 short fibrous processes while these specimens have processes which are longer, slightly less fibrous and sometimes branched distally. It is not apparent if processes are arranged in rows from apex to antapex or not.

SIZE RANGE: Diameter of central body 42-44 microns; length of processes up to 20 microns. Number of specimens measured, 2.

PREVIOUS RECORDS: Cordosphaeridium multispinosum has been recorded from the Eocene London Clay (Davey and Williams 1966b).

LOCALITY OF FIGURED SPECIMEN: Pl. III, Fig. 13: S/2/3 6/97.5 Southwest Potash well; depth 1268-1273 feet.

Genus CORONIFERA Cookson and Eisenack emend. Davey 1969

TYPE SPECIES: Coronifera oceanica Cookson and Eisenack 1958.

Coronifera cf. C. oceanica Cookson and Eisenack 1958

Plate III, Figures 14,15.

DESCRIPTION: Body outline subspherical to subvoidal; body thin walled, bearing hollow processes with lengths about one quarter of the body width, processes weak, open or closed distally, bifurcate or trifurcate; a larger tabular process at the antapex, cylindrical, hollow, open distally with a denticulate margin; apical process branched; archeopyle apical.

REMARKS: Specimens of C. oceanica described by Davey (1969) have processes which are distally closed and joined by low crests. Specimens from the lower part of the Ashville Formation have processes which are open or closed distally and some specimens do not appear to have the low membranes joining the processes.

SIZE RANGE: Overall diameter 36 (57) 75 microns; diameter of the central body 36 (42) 45 microns; maximum length of processes ca. 18 microns. Number of specimens measured, 7.

PREVIOUS RECORDS: Upper Aptian of Germany (Eisenack 1958), Albian of Western Australia (Cookson and Eisenack 1958); upper Gault and Greensand of England (Cookson and Hughes 1964); Cenomanian and Albian of Britain and Albian of the Lower Colorado Group of Saskatchewan (Davey 1969). The known age range is from upper Aptian to Cenomanian (Davey 1969).

LOCALITY OF FIGURED SPECIMENS: Pl. III, Fig. 14: S/5/3 11.5/107 Southwest Potash well; depth 1253-1258 feet. Pl. III, Fig. 15: S/7/1 12/104 Southwest Potash well; depth 1240-1245 feet.

Genus HYSTRICHOKOLPOMA Klumpp emend. Williams and Downie 1966

TYPE SPECIES: Hystrichokolpoma cinctum Klumpp 1953.

Hystrichokolpoma unispinum Williams and Downie 1966

Plate III, Figures 20,21.

1966a Hystrichokolpoma unispinum Williams and Downie, p. 179,
pl. 17, figs. 6,7.

DESCRIPTION: Central body subspherical with thin smooth endophragm continuous beneath processes, and thin smooth periphragm; processes of periphragm smooth to perforate, hollow buccinate and lagenate; tabulation typical of the genus.

SIZE RANGE: Diameter of central body 42 (53) 56 microns; length of processes up to 32 microns; width of processes 3-18 microns. Number of specimens measured, 4.

PREVIOUS RECORDS: (Eocene) London Clay of Britain (Williams and Davey 1966a).

LOCALITY OF FIGURED SPECIMENS: Pl. III, Fig. 21: A/17/1
5.5/95 Alwinsal well; depth 1338-1343 feet. Pl. III, Fig. 20:
A/5/1 2/106.5 Alwinsal well; depth 1403-1408 feet.

Genus LITOSPHAERIDIUM Davey and Williams 1966b

TYPE SPECIES: Litosphaeridium siphoniphorum (Cookson and Eisenack) Davey and Williams 1966 (1966b) (= Hystrichosphaeridium siphoniphorum Cookson and Eisenack 1958).

REMARKS: The inferred tabulation for the genus is 3', 6", 5"', 1p, 1"', with a variable number of sulcal processes.

Litosphaeridium siphoniphorum (Cookson and Eisenack) emend.
Davey and Williams 1966b

Plate III, Figure 17.

- 1958 Hystrichosphaeridium siphoniphorum Cookson and Eisenack, p. 44, pl. 11, figs. 8-10.
- 1963 Hystrichokolpoma sp. B. Baltes, p. 587, pl. 6, figs. 6-8.
- 1963 Hystrichokolpoma sp. A. Baltes, p. 587, pl. 6, figs. 1-5.
- 1964 Hystrichosphaeridium siphoniphorum Cookson and Eisenack in Cookson and Hughes, p. 48, pl. 9, fig. 15.
- 1966b Litosphaeridium siphoniphorum (Cookson and Eisenack) Davey and Williams, p. 80, pl. 7, figs. 7,8.
- 1969 Litosphaeridium siphoniphorum (Cookson and Eisenack) Davey and Williams in Davey, p. 148, pl. 6, figs. 3,4.

DESCRIPTION: Outline of central body subspherical, with a thin endophragm and a thick reticulate periphragm; processes of smooth thin periphragm, cylindrical to subconical with slightly

serrate distal margins; no archeopyle observed; inferred tabulation as for genus.

REMARKS: These specimens possess the thick reticulate periphragm possessed by Litosphaeridium siphoniphorum Cookson and Eisenack 1958.

SIZE RANGE: Diameter of central body 39 (51) 67 microns; length of processes up to 17 microns. Number of specimens measured, 4.

PREVIOUS RECORDS: Upper Albian to lower Cenomanian of England (Eisenack 1958); probable Albian of Britain (Davey and Williams 1966b); (Albian) Lower Colorado of Saskatchewan; the (Cenomanian) upper Woodbine Formation of Texas (Davey 1969).

LOCALITY OF FIGURED SPECIMEN: Pl. III, Fig. 17: S/16/3 17/102.5 Southwest Potash well; depth 1196-1198 feet.

Litosphaeridium sp. A

Plate III, Figure 16,18.

- 1967 Hystrichosphaeridium siphoniphorum Cookson and Eisenack in Clarke and Verdier, p. 55, pl. 11, figs. 1,2.
- 1967 Hystrichosphaeridium siphoniphorum Cookson and Eisenack in Baltes, p. 330, pl. 4, figs. 1-8.

DESCRIPTION: Subspherical central body composed of thin endophragm and thin faintly granular to smooth periphragm; processes composed of smooth periphragm, cylindrical to subconical, open distally, margin slightly serrate; no archeopyle observed; reflected tabulation characteristic of genus.

REMARKS: These specimens do not possess the thick reticulate

periphragm of Litosphaeridium siphoniphorum Cookson and Eisenack 1958. Specimens figured by Clarke and Verdier (1967) and by Baltes (1967) do not show the presence of a thick reticulate periphragm; and appear to be the same as the species described here.

SIZE RANGE: Overall diameter 37 microns; body diameter 26 microns; length of processes up to 9 microns. Number of specimens measured, 1.

PREVIOUS RECORDS: Specimens figured by Clarke and Verdier (1967) come from Cenomanian sediments of Britain; those figured by Baltes (1967) come from Albian sediments of Rumania.

LOCALITY OF FIGURED SPECIMENS: Pl. III, Fig. 16: S/25/2 10.5/105.5 Southwest Potash well; depth 1144-1149. Pl. III, Fig. 18: S/16/3 11/107.5 Southwest Potash well; depth 1196-1198 feet.

Genus OLIGOSPHERIDIUM Davey and Williams 1966b

TYPE SPECIES: Oligosphaeridium tubiferum (White) Deflandre 1946 (= Xanthidium tubiferum complex White 1842).

REMARKS: The reflected tabulation for this genus is 4', 6", 5-6"', 1p, 1'''. It possesses no cingular processes. The number of processes is never more than 18.

Oligosphaeridium albertense (Pocock) Davey and Williams 1966b

Plate III, Figures 19,22.

1962 Hystrichosphaeridium albertense Pocock, p. 82, pl. 15, figs. 226,227.

1964 Hystrichosphaeridium albertense Pocock in Singh, p. 138, pl. 18, fig. 6 only.

1966b Oligosphaeridium albertense (Pocock) Davey and Williams, p. 77.

DESCRIPTION: Body outline subcircular; endophragm and periphragm thin and smooth; processes formed of periphragm, hollow infundibular, flaring and fenestrate distally; no cingular processes; tabulation typical of genus; apical archeopyle.

SIZE RANGE: Diameter of body 56 (62) 64 microns; length of processes 20 (25) 28 microns. Number of specimens measured, 9.

PREVIOUS RECORDS: Lower? to middle Albian of the Mannville Group of Alberta (Singh 1964); reported also from the Lower Cretaceous Garbutt Formation of northern Canada. (Pocock 1962).

LOCALITY OF FIGURED SPECIMENS: Pl. III, Fig. 22: A/5/3 17/99 Alwinsal well; depth 1405-1408 feet. Pl. III, Fig. 19: S/10/1 10.5/108.5 Southwest Potash well; depth 1225-1230 feet.

Oligosphaeridium anthophorum Cookson and Eisenack 1958

Plate IV, Figures 1,3.

For synonymy see Davey (1969, p. 147).

DESCRIPTION: Body outline subspherical to suboval; body wall smooth to slightly granular; processes hollow, buccinate to infundibular, distally flared and perforate; distally margins usually entire; complete specimens possess 18 processes reflecting tabulation characteristic of the genus; the first post cingular (1'') and the posterior intercalary (lp) process are reduced often.

SIZE RANGE: Diameter of central body 41 (47) 49 microns; maximum length of processes 22 (32) 37 microns. Number of specimens measured, 5.

PREVIOUS RECORDS: Upper Jurassic-Lower Cretaceous of Australia (Cookson and Eisenack 1958); upper Barremian to Albian of Germany (Eisenack 1958); Albian of Saskatchewan (Davey 1969).

LOCALITY OF FIGURED SPECIMENS: Pl. IV, Fig. 3: A/13/2
14/104 Alwinsal well; depth 1363-1368 feet. Pl. IV, Fig. I: A/5/1
18/102 Alwinsal well; depth 1403-1408 feet.

Oligosphaeridium complex (White) Davey and Williams 1966b

Plate IV, Figures 2,4-6.

For synonymy see Davey (1969, p. 146).

DESCRIPTION: Central body subspherical to ovoidal; periphragm of central body smooth to slightly granular; processes composed of periphragm, cylindrical most of their length, with expanded funnel shaped distal openings, margin aculeate, the aculei simple or branched, orthogonal, patulate or recurved; processes smooth to faintly fibrous; reflected tabulation as for genus; archeopyle apical with a zig-zag margin.

SIZE RANGE: Diameter of central body 37 (43) 52 microns; length of processes up to 28 microns. Number of specimens measured, 14.

PREVIOUS RECORDS: Upper Valanginian to Aptian of Germany (Eisenack 1958, Gocht 1959); Lower and Upper Cretaceous of Australia (Deflandre and Cookson 1955, Cookson and Eisenack 1958); upper Albian to Senonian of England (White 1842, 1844; Cookson and Hughes 1964); Cenomanian of France (Firtion 1952); Albian and Turonian of Britain, Albian and Cenomanian of Saskatchewan (Davey 1969) and Barremian, Neocomian and Eocene of Britain (Davey and Williams 1966b); known range Neocomian to Eocene.

LOCALITY OF FIGURED SPECIMENS: Pl. IV, Fig. 2: S/25/2

12/110 Southwest Potash well; depth 1144-1199 feet. Pl. IV, Fig. 5:

S/14/2 5/102.5 Southwest Potash well; depth 1203-1208. Pl. IV,

Fig. 6: S/1/3 12/111 Southwest Potash well; depth 1278-1283.

Pl. IV, Fig. 4: S/16/1 19.5/96.5 Southwest Potash well; depth 1196-1198 feet.

Oligosphaeridium pulcherrimum (Deflandre and Cookson) Davey
and Williams 1966b

Plate IV, Figures 7,8.

1955 Hystrichosphaeridium pulcherrimum Deflandre and Cookson,
p. 270, pl. 1, fig. 8.

1966b Oligosphaeridium pulcherrimum (Deflandre and Cookson), Davey
and Williams, p. 75, pl. 10, fig. 9, pl. 11, fig. 5.

DESCRIPTION: Outline of central body oval; endophragm thin and smooth; periphragm thin and smooth; processes cylindrical most of their length becoming infundibular and fenestrate at the distal end; distal margin of processes aculeate and patulate; processes of variable diameter; the lp process smaller than the rest; reflected tabulation conform to that of genus; archeopyle apical with a zig-zag margin.

REMARKS: Some specimens appear to be transitional forms between O. pulcherrimum (Deflandre and Cookson) Davey and Williams 1966b and O. complex (White) Davey and Williams 1966b in that the distal ends of the processes on some specimens are fenestrate, perforate and aculeate while on others they are not perforate or fenestrate but only aculeate. This fact makes separation into two distinct and separate species difficult. More detailed study is needed to determine

whether a reliable separation of the two species can be made or whether the features are truly transitional and should be considered to represent one species. Deflandre and Cookson (1955) and Davey and Williams (1966b) have encountered this problem also.

SIZE RANGE: Diameter of central body 33 (42) 55 microns; length of processes up to 37 microns. Number of specimens measured, 16.

PREVIOUS RECORDS: Wealden of Belgium (Delcourt and Sprumont, 1957, 1959), Cretaceous of France (Valensi 1955); Lower Cretaceous of Australia (Deflandre and Cookson 1954, 1955); Cenomanian of England (Clarke and Verdier 1967) and (Eocene) London Clay of England (Davey and Williams 1966b).

LOCALITY OF FIGURED SPECIMENS: Pl. IV, Fig. 8: S/29/1 5/107 Southwest Potash well; depth 1149-1150 feet. Pl. IV, Fig. 7: A/5/1 6.5/105 Alwinsal well; depth 1403-1408 feet.

Oligosphaeridium reticulatum Davey and Williams 1966b

Plate IV, Figures 9-11, 14.

1966b Oligosphaeridium reticulatum Davey and Williams, p. 74, pl. 7, fig. 10.

DESCRIPTION: Central body subspherical with a finely reticulate endophragm; periphragm of processes smooth to slightly fibrous; processes simple, cylindrical, expanding distally and terminating with an aculeate, patulate to recurved margin; width of processes variable; reflected tabulation typical of the genus; archeopyle apical with a zig-zag margin.

REMARKS: Hystrichosphaeridium albertense Singh 1964, p. 138, pl. 18, fig. 7) is very similar to these specimens; the only notable difference is that the central body is described as smooth whereas Oligosphaeridium reticulatum has a finely reticulate endophragm.

SIZE RANGE: Diameter of central body 47 (48) 52 microns; length of processes up to 28 microns. Number of specimens measured, 4.

PREVIOUS RECORDS: Reported from the Cenomanian of Britain (Davey and Williams 1966).

LOCALITY OF FIGURED SPECIMENS: Pl. IV, Fig. 10: S/7/2 23/104.5 Southwest Potash well; depth 1240-1245 feet. Pl. IV, Fig. 11: S/2/2 6/104 Southwest Potash well; depth 1268-1273. Pl. IV, Fig. 9: A/5/3 14/95 Alwinsal well; depth 1403-1408 feet. Pl. IV, Fig. 14: A/5/1 13.5/108.5 Alwinsal well; depth 1403-1408 feet.

Genus POLYSPHAERIDIUM Davey and Williams 1966b

TYPE SPECIES: Polysphaeridium subtile Davey and Williams 1966. (1966b)

REMARKS: The number of processes per plate area is greater than one. Processes are hollow and can be open or closed distally. The archeopyle, if present, is apical with an angular margin. Reflected tabulation is difficult to interpret because of the large number of processes but is basically the same as Hystrichosphaeridium tubiferum (Ehrenberg).

Polysphaeridium sp. A

Plate IV, Figure 13.

DESCRIPTION: Body outline ovoidal to subspherical, composed of smooth endophragm and granular periphragm; processes are tubiform to buccinate with an entire distal margin, two processes per plate area; archeopyle apical; tabulation probably 4", 6c, 4"', 1'''.

REMARKS: Polysphaeridium pumilum Davey and Williams 1966b is similar but the length of its processes are less than half the maximum diameter of the central body and also the central body is smooth.

SIZE RANGE: Overall length 56 microns; overall width 43 microns; length of processes up to 13 microns. Number of specimens measured, 2.

LOCALITY OF FIGURED SPECIMEN: Pl. IV, Fig 13: S/16/3 17/98.5 Southwest Potash well; depth 1196-1198 feet.

Genus PROLIXOSPHAERIDIUM Davey et al. 1966

TYPE SPECIES: Prolixosphaeridium deirense Davey et al. 1966.

REMARKS: Mesozoic dinoflagellate cysts with an elongate central body and an apical archeopyle. The number of processes exceeds 30 and processes are closed or open distally.

Prolixosphaeridium sp. A

Plate IV, Figure 12.

DESCRIPTION: Body outline elongate ovoidal to elliptical; apical portion lost in formation of an apical archeopyle; antapical end rounded with two prominent spines; remaining processes form rows (about 6) encircling the body; possible cingulum indicated by a larger

gap between the third and fourth rows of processes; processes closed, tapering distally to a point, simple or bifurcate; surface of body granulate.

REMARKS: Prolixosphaeridium deirense Davey et al. 1966 differs from Prolixosphaeridium sp. A in bearing a dense cover of short spinelets and is smaller. P. granulorum (Deflandre) Davey et al. 1966 differs in having fewer processes and only one antapical process.

SIZE RANGE: Overall length (without apical portion) 88 microns; length of central body 66 microns; breadth of central body 36 microns; length of processes up to 20 microns. Number of specimens measured, 1.

LOCALITY OF FIGURED SPECIMEN: Pl. IV, Fig. 12: S/27/3 7.5/105 Southwest Potash well; depth 1134-1139 feet.

Genus SYSTEMATOPHORA Klement 1960

TYPE SPECIES: Systematophora areolata Klement 1960.

Systematophora schindewolfi (Alberti) Neale and Sarjeant 1962

Plate V, Figure 7.

For synonymy see Sarjeant (1966b, p. 209).

DESCRIPTION: Central body spherical to subspherical; surface faintly granular, bearing numerous fenestrate, flared, cylindrical processes, processes very fine and lace-like, processes plate centered reflecting tabulation typical for the genus; no archeopyle observed.

REMARKS: This species is distinguished by the lace-like nature of the processes. Only one complete specimen was observed.

SIZE RANGE: Overall diameter 114 microns; diameter of central body 60 microns; length of processes 25-30 microns. Number of specimens measured, 1.

PREVIOUS RECORDS: Upper Barremian to ?Senonian of Germany (Alberti 1961); middle Barremian of Britain (Sarjeant 1966b).

LOCALITY OF FIGURED SPECIMEN: Pl. V, Fig. 7: S/16/1 23/108.5 Southwest Potash well; depth 1196-1198 feet.

Genus TANYOSPHAERIDIUM Davey and Williams 1966b

TYPE SPECIES: Tanyosphaeridium variecalamum Davey and Williams 1966.(1966b)

Tanyosphaeridium variecalamum Davey and Williams 1966b

Plate V, Figures 1,2,5.

1966b Tanyosphaeridium variecalamum Davey and Williams, p. 98, pl. 6, fig. 7.

DESCRIPTION: Central body composed of endophragm surrounded by granular periphragm; processes composed of smooth periphragm, tapering before terminating, the distal margin serrate and expanded; the number of processes is about 20; archeopyle apical; two antapical processes.

REMARKS: T. regulare Davey and Williams 1966b differs in having more processes and T. isocalamus (Deflandre and Cookson) Davey and Williams 1966b differs in having wider processes and a more simple distal termination.

SIZE RANGE: Length of central body 33 (35) 44 microns; width 19 (21) 24 microns; length of processes 8-16 microns. Number of specimens measured, 6.

PREVIOUS RECORDS: Cenomanian of England (Davey and Williams 1966); Cenomanian, Albian and Turonian of England and Albian of Saskatchewan (Davey 1969).

LOCALITY OF FIGURED SPECIMENS: Pl. V, Fig. 1: S/27/2 13/94 Southwest Potash well; depth 1134-1139 feet. Pl. V, Fig. 5: S/28/1 12.5/100 Southwest Potash well; depth 1129-1134 feet. Pl. V, Fig. 2: S/16/3 16.5/101.5 Southwest Potash well; depth 1196-1198 feet.

Tanyosphaeridium sp. A

Plate V, Figure 3.

DESCRIPTION: Central body elongate composed of thin endophragm and granular periphragm; processes composed of smooth periphragm, buccinate, processes numbering about 18 on specimens which have lost the apical portion; archeopyle apical.

REMARKS: Tanyosphaeridium isocalamus (Deflandre and Cookson) Davey and Williams resembles this species but its processes do not flare distally as with this species and the periphragm appears to be smooth.

SIZE RANGE: Length of central body (without apical portion) 50 microns; width 30 microns; length of processes up to 16 microns. Number of specimens measured, 1.

LOCALITY OF FIGURED SPECIMEN: Pl. V, Fig. 3: S/13/3 18/106 Southwest Potash well; depth 1208-1213 feet.

Cyst-Family AREOLIGERACEAE Evitt emend. Sarjeant and Downie 1966

Genus CYCLONEPHELIUM Deflandre and Cookson emend. Williams and Downie 1966b

TYPE SPECIES: Cyclonephelium compactum Deflandre and Cookson 1955.

REMARKS: Tabulation has not been established for this genus beyond the fact, that there are four apical and six precingular plates.

Cyclonephelium distinctum Deflandre and Cookson 1955

Plate V, Figures 4,6.

For synonymy see Davey (1969, p. 166).

DESCRIPTION: Body outline circular to subcircular; apical archeopyle formed by dehiscence along zig-zag line, operculum generally missing; antapex rounded; surface of body ornamented with numerous short solid processes, the apices of which are bluntly pointed, capitate or forked, restricted to margin of body with a central portion free of processes; surface of body punctate.

REMARKS: Cyclonephelium compactum Deflandre and Cookson 1955 most closely resembles this species; it differs in its smaller size, more regular arrangement of the membrane and generally the processes are more restricted to the margins of the body.

SIZE RANGE: Length of body (without apical portion) 52 (73) 84 microns; width 54 (76) 101 microns; length of processes 6 (10) 20 microns. Number of specimens measured, 15.

PREVIOUS RECORDS: Upper Valanginian to Hauterivian of Germany (Gocht 1959); upper Hauterivian to Aptian, ?lower Albian of Germany (Alberti 1961); Albian to Senonian, Australia (Cookson and Eisenack 1962b, Deflandre and Cookson 1955); Upper Cretaceous of Canada (Manum and Cookson 1964), Albian and Cenomanian strata of the Lower

Colorado Group of Saskatchewan and Cenomanian sediments of Britain (Davey 1969).

LOCALITY OF FIGURED SPECIMENS: Pl. V, Fig. 6: S/13/2 7/97 Southwest Potash well; depth 1220-1225 feet. Pl. V, Fig. 4: A/13/2 10/91.5 Alwinal well; depth 1363-1368 feet.

Cyclonephelium eisenacki Davey 1969

Plate V, Figures 8,9,11,13.

For synonymy see Davey (1969, p. 170).

DESCRIPTION: Body outline subtriangular to subcircular; apical horn well developed, conical with concave sides; antapical horns if present reduced, often only one is evident; surface ornamented with low crests and short capitate processes, crests often broken and irregular, central area of both dorsal and ventral surfaces marked by a circular area devoid of ornamentation, or an area of less dense ornamentation; a poorly marked cingulum, outlined by crests, is occasionally present; archeopyle apical with operculum often not completely detached.

REMARKS: For remarks and comparisons see Davey (1966, p. 171).

SIZE RANGE: Length of body (without apical portion) 61 (65) 66 microns (6 specimens); length (complete specimen 75 (78) 82 microns (6 specimens); width 66 (75) 107 microns (12 specimens).

PREVIOUS RECORDS: Lower Cretaceous Lower Colorado Group of Saskatchewan (Davey 1969).

LOCALITY OF FIGURED SPECIMENS: Pl. V, Fig. 11: S/27/1 14/101 Southwest Potash well; depth 1134-1139 feet. Pl. V, Fig. 9: A/5/2 20/101.5 Alwinal well; depth 1403-1408 feet. Pl. V, Fig. 8: S/16/2 17/106 Southwest Potash well; depth 1196-1198 feet. Pl. V, Fig. 13:

S/27/3 17/106 Southwest Potash well; depth 1134-1139 feet.

Cyclonephelium sp. A

Plate V, Figure 10.

DESCRIPTION: Body outline subcircular to subtriangular; antapex with a pointed protrusion on one side; strong ornamentation restricted to the circumferential zone, consisting of a very thin membrane supported at intervals by strong processes, membrane with fine radial striae; archeopyle apical, formed by loss of the apex, outline zig-zag; body surface subgranular.

REMARKS: Cyclonephelium compactum Deflandre and Cookson 1955 is similar but has a more regularly developed and finer membraneous ornamentation; Cyclonephelium membraniphorum Cookson and Eisenack 1962a is most like this species but has a more uniform, more continuous membrane development.

SIZE RANGE: Length of body (without apical portion) 95 (115) 125 microns; width of body 90 (125) 130 microns. Number of specimens measured, 5.

LOCALITY OF FIGURED SPECIMEN: Pl. V, Fig. 10: S/13/3 7.5/100.5 Southwest Potash well; depth 1208-1213 feet.

Cyclonephelium sp. B

Plate V, Figure 17.

DESCRIPTION: Body outline subcircular to subquadrate; apex with concave sides extending into a broadly based conical apical horn with tuft of ornamentation; antapex rounded; surface ornamentation restricted to the circumferential zone, consisting of low, short, capitate spines and fine membranes forming an irregular polygonal pattern

of low membraneous ridges; surface of body granulate to perforate.

REMARKS: Tenua? sp. Eisenack (1958, p. 5, fig. 16) resembles this form but differs in that the processes are uniformly distributed over the whole surface. Looking at Eisenack's figure however ornamentation of Tenua? sp. appears to be sparser in the central portion of the body surface while in the form described here processes are definitely restricted to the circumference.

The tuft of ornamentation at the end of the apical horn is particularly distinctive in this species.

SIZE RANGE: Length of body (complete specimen) 62 microns; width of body 54 microns; height of processes 1-2 microns. Number of specimens measured, 1.

LOCALITY OF FIGURED SPECIMEN: Pl. 5, Fig. 17: S/1/3 11/96 Southwest Potash well; depth 1278-1283 feet.

Cyst-Family HYSTRICHOSPHAERACEAE O. Wetzel emend.
Sarjeant and Downie 1966

Genus HYSTRICHOSPHAERA O. Wetzel emend. Davey and Williams 1966b

TYPE SPECIES: Hystrichosphaera ramosa (Ehrenberg) O. Wetzel 1937
(= Xanthidium ramosa Ehrenberg 1838).

REMARKS: Davey and Williams (1966a) have emended the generic diagnosis to include reference to the reflected tabulation of 3-4', 6", 6c, 5"', 0-1p, 1"', and to the presence of sutural processes in many species.

Hystrichosphaera cingulata var. reticulata Davey and Williams
1966a

Plate VI, Figures 1-3.

For synonymy see Davey (1969, p. 172).

DESCRIPTION: Central body subcircular to semicircular; central body formed of smooth endophragm and reticulate periphragm; gonol processes do not extend beyond sutural crests, processes acting like supporting structures for crests, processes bifurcate.

REMARKS: Hystrichosphaera cingulata (O. Wetzel) Deflandre and Cookson 1955 is characterized by well developed crests beyond which the gonol processes do not protrude, the latter acting as supporting structures.

SIZE RANGE: Diameter of central body 37 (44) 45 microns; height of crests up to 9 microns. Number of specimens measured, 4.

PREVIOUS RECORDS: Reported as infrequent in the middle and upper Cenomanian of England (Davey and Williams 1966a); Turonian and Senonian from the Isle of Wight (Clarke and Verdier 1967).

LOCALITY OF FIGURED SPECIMENS: Pl. VI, Fig. 3: S/37/2 9.5/105 Southwest Potash well; depth 1080-1085 feet. Pl. VI, Fig. 2: S/37/2 8.5/104 Southwest Potash well; depth 1080-1085 feet. Pl. VI, Fig. 1: S/8/2 15/105 Southwest Potash well; depth 1235-1240 feet.

Hystrichosphaera ramosa (Ehrenberg) var. ramosa
Davey and Williams 1966a

Plate VI, Figures 4,8.

For synonymy see Davey and Williams (1966a, p. 33).

DESCRIPTION: Body outline ovoidal, bearing gonol and a small number of sutural processes; distally processes bifurcate or trifurcate, usually with small bifid terminations, processes tapering to subconical in shape; usually two gonol processes between adjacent cingular plates

connected with a well developed membrane; a distinctive simple apical process; archeopyle precingular.

REMARKS: The simple apical process is a diagnostic feature.

SIZE RANGE: Diameter of central body 32-56 microns; length of processes up to 20 microns. Number of specimens measured, 3.

PREVIOUS RECORDS: This species has a known stratigraphic range from Upper Jurassic (Oxfordian) to Eocene (Ypresian) Davey and Williams 1966a; Cenomanian of Britain and Texas and Albian and Cenomanian of the Lower Colorado Group of Saskatchewan (Davey 1969).

LOCALITY OF FIGURED SPECIMENS: Pl. VI, Fig. 4: S/19/1 22/100 Southwest Potash well; depth 1181-1186 feet. Pl. VI, Fig. 8: S/27/2 12.5/101 Southwest Potash well; depth 1134-1139 feet.

Hystrichosphaera ramosa var. gracilis Davey and Williams 1966a

Plate VI, Figures 5,6.

For synonymy see Davey (1969, p. 172).

DESCRIPTION: Outline of central body oval; body wall smooth, thin, bearing gonial and sutural processes; processes long and slender usually bifurcating or trifurcating, terminating with a small bifurcation; apical process long and slender terminating with a small bifurcation; archeopyle precingular.

REMARKS: The slender long processes are distinctive.

SIZE RANGE: Diameter of central body 40 x 46 microns; length of processes up to 16 microns. Number of specimens measured, 7.

PREVIOUS RECORDS: Reported to range from Cenomanian of England (Davey and Williams 1966a) to Miocene of Australia (Deflandre and Cookson 1955).

LOCALITY OF FIGURED SPECIMENS: Pl. VI, Fig. 6: S/16/3

12.5/103.5 Southwest Potash well; depth 1196-1198 feet. Pl. VI,

Fig. 5: A/7/2 6/109 Alwinsal well; depth 1393-1398 feet.

Hystrichosphaera ramosa var. granomembranacea
Davey and Williams 1966a

Plate VI, Figures 7,9.

1966a Hystrichosphaera ramosa var. granomembranacea Davey and Williams,
p. 37, pl. 3, fig. 4.

DESCRIPTION: Central body oval; processes trifurcate forming recurved spines and extending well above suturecrests; plate margins reflect tabulation, typical for genus, outlined by sutural crests or membranes; gonial and sutural processes; body surface granular; membranes faintly reticulate; archeopyle precingular, formed by loss of reflected plate 3".

SIZE RANGE: Diameter of central body 33 (39) 45 microns; length of processes 8 (10) 15 microns. Number of specimens measured, 8.

PREVIOUS RECORDS: Eocene of England (Davey and Williams 1966a).

LOCALITY OF FIGURED SPECIMENS: Pl. VI, Fig. 7: S/27/2 20.102 Southwest Potash well; depth 1134-1139 feet. Pl. VI, Fig. 9: A/7/3 8.5/103 Alwinsal well; depth 1393-1398 feet.

Hystrichosphaera ramosa var. membranacea (Rossignol)
Davey and Williams 1966a

Plate VI, Figure 10.

1964 Hystrichosphaera furcata var. membranacea Rossignol, p. 86,
pl. 1, figs. 4,9,10; pl. 3, figs. 7,12.

1966a Hystrichosphaera ramosa var. membranacea Rossignol, Davey
and Williams, p. 33, pl. 4, figs. 8,12.

DESCRIPTION: Outline of central body oval to suboval; central body smooth, with membranes variable in height and development uniting processes, better developed in cingular and polar areas, cingular processes bifurcate, sutural and gonial processes trifurcate; processes flat, two large antapical processes.

SIZE RANGE: Diameter of central body 31(35) 45 microns; length of processes 11 (15) 20 microns. Number of specimens measured, 7.

PREVIOUS RECORDS: Recorded from the Eocene London Clay (Sarjeant and Downie 1966a) from the Pleistocene (Rossignol 1964).

LOCALITY OF FIGURED SPECIMEN: Pl. VI, Fig. 10: S/16/3
19.5/110 Southwest Potash well; depth 1196-1198 feet.

Hystrichosphaera ramosa var. reticulata Davey and Williams 1966a

Plate VI, Figure 11.

1966a Hystrichosphaera ramosa var. reticulata Davey and Williams, p. 38, pl. 1, figs. 2,3.

DESCRIPTION: Central body suboval to polygonal, composed of smooth endophragm and reticulate periphragm; processes gonial, usually subconical with trifurcate terminations; processes joined by low granular to finely reticulate sutural membranes; processes between cingular plates trifurcate usually with trifurcate terminations; archeopyle precingular, formed by the loss of reflected plate 3".

REMARKS: These specimens are finely reticulate grading to granular.

SIZE RANGE: Diameter of central body 34 (41) 47 microns; length of processes up to 8 microns. Number of specimens measured, 5.

PREVIOUS RECORDS: Present in small numbers throughout the Cenomanian of England (Davey and Williams 1966a); recorded from the Lower Cretaceous (Albian) of Saskatchewan (Davey 1969).

LOCALITY OF FIGURED SPECIMEN: Pl. VI, Fig. 11: S/18/3 13/107 Southwest Potash well; depth 1186-1191 feet.

Hystrichosphaeridium ramosa var. indet.

Plate VI, Figure 12.

DESCRIPTION: Outline of central body oval to suboval; wall of central body thin, smooth; gonial and sutural processes extending beyond sutural crests; gonial processes trifurcate, sutural processes bifurcate; two large processes on antapical end.

REMARKS: The two large antapical processes separate this variety from others.

SIZE RANGE: Diameter of central body 49 x 51 microns; length of processes up to 7 microns. Number of specimens measured, 1.

LOCALITY OF FIGURED SPECIMEN: Pl. VI, Fig. 12: A/17/2 11/104.5 Alwinal well; depth 1338-1343 feet.

Genus HYSTRICHODINIUM Deflandre emend. Sarjeant 1966a

TYPE SPECIES: Hystrichodinium pulchrum Deflandre 1935.

REMARKS: Tabulation for this genus is in general accord with the Gonyaulax pattern. It differs from Helioidinium in the rounded,

unflattened, nature of the spines.

Hystrichodinium cf. H. oligacanthum Deflandre and Cookson 1955

Plate VI, Figure 14.

DESCRIPTION: Proximo-chorate cyst; outline rounded to polygonal; epitract a little larger than hypotract; cingulum helicoidal, no appendages on its upper rim but about 6 on lower rim; processes about 1/2 the diameter of the body; hollow, tapering to a point distally, smooth, rounded; plate areas not well defined, indicated by low ridges; surface of body scabrate to slightly spinose.

REMARKS: No archeopyle observed. If present it is precingular, according to Sarjeant (1966a).

SIZE RANGE: Length of central body 47 (51) 69 microns; breadth 37 (47) 56 microns; overall length of processes 22 (29) 41 microns. Number of specimens measured, 3.

PREVIOUS RECORDS: H. oligacanthum has been recorded from Lower Cretaceous strata of New South Wales, Australia (Deflandre and Cookson 1955).

LOCALITY OF FIGURED SPECIMEN: Pl. VI, Fig. 14: S/16/3 7/95 Southwest Potash well; depth 1196-1198 feet.

Cyst-Family CTENIDODINIACEAE Sarjeant and Downie 1966

Genus DINOPTERYGIUM Deflandre 1935

TYPE SPECIES: Dinopterygium cladoides Deflandre 1935.

REMARKS: Deflandre (Norris and Sarjeant 1965) has confirmed the opinion of Sarjeant that Oodnadattia tuberculata Eisenack and Cookson is a junior synonym of Dinopterygium cladoides Deflandre.

Dinopterygium cladoides Deflandre 1935

Plate V, Figure 12.

- 1955 Dinopterygium cladoides Deflandre, in Deflandre and Cookson, p. 261, pl. 1, fig. 2.
- 1960 Oodnadattia tuberculata Eisenack and Cookson, p. 6, pl. 2, fig. 10-14.

DESCRIPTION: Body outline circular to oval with an embayment formed by the longitudinal furrow, broader than long; cingulum circular and narrow bordered by low membraneous flanges about 12-14 microns wide, plates of epitract and hypotract bordered by low membraneous ridges; hypotract contains one large apical plate 1"', 5 post cingular plates 5 to 6' intermediate plates, the post cingular plates are tuberculate and intermediate plates are smooth; equatorial membranes smooth.

REMARKS: The plate arrangement has not been distinctly established for the epitract but seems to conform to that of specimens described by Eisenack and Cookson (1960).

SIZE RANGE: Overall diameter 68 (76) 101 microns. Number of specimens measured, 11.

PREVIOUS RECORDS: Senoniam (?) of France (Deflandre 1935); Albion of New South Wales and southern Australia (Eisenack and Cookson

1960).

LOCALITY OF FIGURED SPECIMEN: Pl. V, Fig. 12: S/17/3

9/102 Southwest Potash well; depth 1191-1196 feet.

Cyst-Family DEFLANDREACEAE Eisenack emend.
Sarjeant and Downie 1966

Genus DEFLANDREA Eisenack emend. Williams and Downie 1966b

TYPE SPECIES: Deflandrea phosphoritica Eisenack 1938.

REMARKS: The diagnosis for this genus contains several points which have been overlooked at various times when assigning specimens to genera. This genus contains cavate cysts with one apical and two antapical horns; the periphragm is smooth or granular, the archeopyle intercalary and tabulation when decipherable is peridinoid.

Deflandrea cf. D. cincta Cookson and Eisenack 1958

Plate V, Figure 16.

DESCRIPTION: Outer body separated by a relatively wide transverse girdle; a short longitudinal furrow is situated on the ventral surface of the epitract; the epitract is convex laterally and narrows rather abruptly towards an apical horn; hypotract prolonged on one side into a conical, pointed antapical horn and on the other side into a short blunt reduced antapical horn; surface of the outer body granular.

The inner body is smooth, broadly oval, extending laterally almost to the wall of the outer body.

REMARKS: Deflandrea cincta, Cookson and Eisenack 1958, differs in that it is broader, its longitudinal furrow is short and restricted to the hypotract, and its inner body extends laterally to the outer membrane. The width of Ashville specimens is less than the type specimen.

SIZE RANGE: Length of body 66 (73) 82 microns; width of body 43 (45) 47 microns; diameter of inner body 39 (43) 51 microns. Number of specimens measured, 3.

PREVIOUS RECORDS: Deflandrea cincta has been recorded from Lower Cretaceous (upper Neocomian to lower Aptian) sediments of Australia (Cookson and Eisenack 1958); known range is middle Hauterivian to middle Albian (Sarjeant 1966b).

LOCALITY OF FIGURED SPECIMEN: Pl. V, Fig. 16: S/5/11 15/105.5 Southwest Potash well; depth 1253-1258 feet.

Deflandrea pirnaensis Alberti 1959

Plate V, Figure 14.

1959 Deflandrea pirnaensis Alberti, p. 100, pl. 8, figs. 1-5.

DESCRIPTION; Body outline pentagonal, divided into an epittract and a hypotract by a distinct relatively wide cingulum; epittract prolonged into a pointed apical projection; hypotract more rounded with two unequally developed antapical horns, one very short and reduced, the other broad at the base extending into a sharp point distally; a faint indication of tabulation above and below cingulum marked by

faint lines, short longitudinal furrow restricted to hypotheca; surface of the outer body faintly granulate, covered with very fine short hair-like projections.

Inner body elongate, oval, extending almost to the margins of the outer body laterally such that it almost fills the outer body except in the area of the apical horn and larger antapical projection.

REMARKS: Deflandrea sverdrupiana Manum 1963 is somewhat similar but differs in having cone like processes, more distinct indication of tabulation and the inner body does not extend into the apical and antapical regions so far.

SIZE RANGE: Length of body 82 (89) 105 microns; width of central body 52 (55) 62 microns; diameter of central body 51 (53) 56 microns. Number of specimens measured, 6.

PREVIOUS RECORDS: This species has been recorded in sediments ranging in age from middle Albian to Turonian and middle Turonian to Santonian (Sarjeant 1966 and Norris 1965).

LOCALITY OF FIGURED SPECIMEN: Pl. V, Fig. 14: S/6/2 7.5/105 Southwest Potash well; depth 1249-1253 feet.

Deflandrea cf. D. pirnaensis Alberti 1959

Plate V, Figure 15.

DESCRIPTION: Outer body elongate, pentagonal; epitract with straight to slightly convex sides narrowing abruptly to form a short

cylindrical apical horn; hypotract smaller than epitract, extending into two antapical horns, one very short and blunt, the other long conical and pointed; cingulum well developed, short indistinct longitudinal furrow restricted to hypotract; no tabulation apparent; no archeopyle observed; surface of outer body granulate.

Inner body subspherical to ovoidal, its longitudinal axis parallel to the longitudinal axis of the outer body; not extending laterally to the margins of the outer body; approximately the same distance from the antapical end but more remote from the apical end.

REMARKS: The central body extends higher into the apical end of specimens recorded by Alberti.

SIZE RANGE: Length of body 66 (73) 108 microns; width of body 41 (50) 64 microns; diameter of inner body 49 microns. Number of specimens measured, 15.

PREVIOUS RECORDS: D. pirnaensis has been recorded in sediments ranging in age from middle Albian to Turonian and middle Turonian to Santonian (Sarjeant and Norris 1965).

LOCALITY OF FIGURED SPECIMEN: Pl. V, Fig. 15: S/16/2 10.5/106.5 Southwest Potash well; depth 1196-1198 feet.

Cyst-Family NELSONIELLACEAE Eisenack emend.
Sarjeant and Downie 1966

Genus SCRINIODINIUM Klement 1957

TYPE SPECIES: Scriniodinium crystallinum Deflandre 1938

Klement (= Gymnodinium crystallinum Deflandre 1938).

REMARKS: This genus includes two sub-genera based on the presence or absence of tabulation (Klement 1960). Sub-genus Endoscrinium Klement 1960 includes species in which tabulation can be deduced while sub-genus Scriniodinium encompasses species with no apparent tabulation.

Sub-Genus ENDOSCRINIUM Klement 1960

TYPE SPECIES: Scriniodinium galeritum (Deflandre) Klement 1957 (Gymnodinium galeritum Deflandre 1938) (1938b).

Scriniodinium (Endoscrinium) campanula Gocht 1959

Plate VI, Figure 18.

For synonymy see Clarke and Verdier (1967, p. 28-29).

DESCRIPTION: Body outline subquadrate; epittract with a conical apical horn; hypottract rounded to conical; cingulum circular, deeply folded; a narrow median fold runs from the antapex to the cingulum; a small, roughly circular, opening in the outer body wall is present on one side of the lower hypottract; body surface faintly granulate; tabulation present but difficult to interpret.

Inner body sub-oval with an apical protrusion extending into the base of the apical horn of the outer body; separated from the

outer body wall by quite a wide margin; surface granular.

REMARKS: Cookson and Hughes (1964) studied transverse and longitudinal sections cut through the body. They note that one or two lines running parallel to and at some distance from the edge of the shell are clearly seen, but instead of regarding these as indicating the limit of an inner capsule they suggest this appearance is due to the steepness of the gradient of the dorsal convexity of the body.

In these specimens the central body does seem to be distinct and the surface is slightly more granulate than the outer body but none has been sectioned.

SIZE RANGE: Overall length 100 (103) 103 microns; width 84 (86) 87 microns; inner body ca. 66 microns; length of apical horn ca. 30 microns. Number of specimens measured, 3.

PREVIOUS RECORDS: Reported from sediments ranging from Valanginian to Aptian of Germany (Gocht 1959, Alberti 1961); ranges from upper Albian to lower Cenomanian of England (Cookson and Hughes 1964); Cenomanian of England (Clarke and Verdier 1967).

LOCALITY OF FIGURED SPECIMEN: Pl. VI, Fig. 18: A/15/2
9/111.5 Alwinsal well; depth 1353-1358 feet.

Sub-Genus SCRINIODINIUM Klement 1960

TYPE SPECIES: Scriniodinium crystallinum (Deflandre) Klement 1957
(Gymnodinium crystallinum Deflandre 1938). (1938b)

Scriniodinium (Scriniodinium) cf. S. ceratophorum Cookson and Eisenack 1960

Plate VI, Figure 21.

DESCRIPTION: Body outline subovoidal to subquadrate; epitract triangular, larger than hypotract; hypotract rounded; cingulum represented by a broad fold; body membrane granular to pseudo-reticulate; a large precingular archeopyle-like feature present between the base of the apical horn and the cingulum; no tabulation apparent. Inner body not plainly delimited but it has a small apical prominence and it almost fills the outer body.

REMARKS: Scriniodinium ceratophorum Cookson and Eisenack 1960 is considerably smaller than Ashville specimens.

SIZE RANGE: Overall length 159 (165) 168 microns; width 114 (129) 138 microns; length of apical horn ca. 15 microns. Number of specimens measured, 4.

PREVIOUS RECORDS: Cookson and Eisenack (1960) have reported S. ceratophorum in sediments ranging from Oxfordian to lower Kimmeridgian in Australia.

LOCALITY OF FIGURED SPECIMENS: Pl. VI, Fig. 21: S/27/3 8/106 Southwest Potash well; depth 1134-1139 feet.

Scriniodinium (Scriniodinium) eurypylum Manum and Cookson 1964

Plate VI, Figure 13.

1964 Scriniodinium eurypylum Manum and Cookson, p. 20, pl. 4, fig. 4.

DESCRIPTION: Body outline pentagonal; divided by a cingulum into an epitract which extends into a short blunt conical apical horn and a hypotract with two inconspicuous small horn-like projections, one blunt, the other short and pointed; wall of outer body thin and smooth; inner body almost completely fills the outer body and in close contact with outer body wall; surface of inner body faintly granulate; archeopyle apparently precingular.

REMARKS: Manum and Cookson (1964) remark that the "form is rather Deflandrea-like in general appearance, however it must be referred to Scriniodinium because of the possession of a precingular archeopyle." The length range (65-81 microns) given by Manum and Cookson is extended slightly.

SIZE RANGE: Length 64 (77) 86 microns; width 51 (52) 54 microns. inner body 51-53 microns; length of apical horn ca. 8 microns. Number of specimens measured, 4.

PREVIOUS RECORDS: Upper Cretaceous from the Hassel Formation, Ellef Ringnes Island (Manum and Cookson 1964).

LOCALITY OF FIGURED SPECIMEN: Pl. VI, Fig. 13: S/22/2 13/95 Southwest Potash well; depth 1160-1165 feet.

Scriniodinium (Scriniodinium) sp. A

Plate VI, Figure 16.

DESCRIPTION: Body outline elongated, pentagonal; apex extending into an acute apical horn; antapex extended with two un-

equally developed antapical horns; body membrane thin and smooth; cingulum faintly developed, tendency to split along the upper side of the cingulum to form a precingular archeopyle extending from the cingulum to the base of the apical horn; no tabulation apparent; inner body spherical, extending to the outer body wall laterally but remote from the apex and antapex.

REMARKS: Scriniodinium eurypylum Manum and Cookson 1964 differs from this form in that the inner body almost completely fills the outer body.

SIZE RANGE: Length 64-66 microns; breadth 55-58 microns.

Number of specimens measured, 2.

LOCALITY OF FIGURED SPECIMEN: Pl. VI, Fig. 16: S/36/2 14/109.5 Southwest Potash well; depth 1085-1090 feet.

Scriniodinium (Scriniodinium) sp. B

Plate VI, Figure 17.

DESCRIPTION: Body outline rounded pentagonal; a wide cingulum dividing the body into an epitract and hypotract; epitract extends into a broadly conical apical horn; hypotract with two well developed blunt apical projections; body surface faintly granulate; no indication of tabulation; longitudinal furrow well developed extending $\frac{3}{4}$ of length of epitract from cingulum; inner body spherical, smooth to faintly granulate, in contact with the outer body wall laterally; archeopyle wide, apparently precingular extending from cingulum to the base of

the apical horn.

REMARKS: Due to the presence of what appears to be a pre-cingular archeopyle the specimen is referred to Scriniodinium rather than Deflandrea which in other respects it resembles closely.'

SIZE RANGE: Length 75 (79) 84 microns; width 52 (54) 58 microns; length of apical horn ca. 13 microns; antapical horns ca. 9 microns and 13 microns. Number of specimens measured, 5.

LOCALITY OF FIGURED SPECIMEN: Pl. VI, Fig. 17: S/27/2 13/96.5 Southwest Potash well; depth 1134-1139 feet.

Cyst-Family HEXAGONIFERACEAE Sarjeant and Downie 1966

Genus ASCODINIUM Cookson and Eisenack 1960

TYPE SPECIES: Ascodinium acrophorum Cookson and Eisenack 1960.
(1960a)

REMARKS: Ascodinium has an apical archeopyle differing from Deflandrea which has an intercalary archeopyle and Scriniodinium in which the archeopyle is preingular.

Ascodinium verrucosum Cookson and Hughes 1964

Plate VI, Figures 19,20.

1964 Ascodinium verrucosum Cookson and Hughes, p. 41, pl. 5, figs. 4-7.

DESCRIPTION: Body outline longer than broad with convex sides; apex forms rounded cap-like projection; antapex forms a prominent projection with an oblique base which is concave inward; cingulum circular with a short longitudinal furrow present on the hypotract; body surface ornamented by verrucae; archeopyle apical, formed by loss of the cap-like apical portion, inner body extends laterally to the walls of the outer body and extends into the apex except for a small area formed by the apical horn; antapically it extends to the base of the antapical projection.

REMARKS: Considerable variation in size of the outer body and density of ornamentation has been observed. The same was found in the samples from the Cambridge Greensand (Cookson and Hughes 1964).

It is interesting to note the Ascodinium verrucosum is one of the commoner forms in the Cambridge Greensand and Chalk Marl of Britain as it is in the upper part of the Southwest Potash Bredenbury bore-hole.

SIZE RANGE: Overall length 64 (71) 77 microns; length of body without apical portion 52 (57) 64 microns; width 47 (51) 64 microns. Number of specimens measured, 20.

PREVIOUS RECORDS: Ascodinium cf. verrucosum was reported from the Lower Cretaceous of Montana (Evitt 1963), reported from the Cambridge Greensand and Chalk Marl, upper Gault of Britain by Cookson and Hughes (1964).

LOCALITY OF FIGURED SPECIMENS: Pl. VI, Fig. 20: S/37/2

15.5/112 Southwest Potash well; depth 1080-1085 feet. Pl. VI, Fig. 19:

S/37/2 15/112 Southwest Potash well; depth 1080-1085 feet.

Cyst-Family PSEUDOCERATIACEAE Eisenack 1961 emend.
Sarjeant and Downie 1966

Genus PSEUDOCERATIUM Gocht 1957

TYPE SPECIES: Pseudoceratium pelliferum Gocht 1957.

REMARKS: Pseudoceratium is subdivided into sub-genus
Pseudoceratium, forms without determinable tabulation, and sub-genus
Eopseudoceratium, forms with a determinable tabulation of 6', 5a,
6'', 6''', ?4pc, 1 v, 1''''.

Sub Genus EOPSEUDOCERATIUM Neale and Sarjeant 1962

TYPE SPECIES: Pseudoceratium gochti Neale and Sarjeant 1962.

Pseudoceratium (Eopseudoceratium) sp. A

Plate VII, Figures 1-3.

DESCRIPTION: Body outline subtriangular with an oblique base
and convex sides; apical horn long and rounded at the distal end;
two widely divergent unequal antapical horns; a distinct cingulum
bordered by ridges of ornamentation; small longitudinal furrow; body
surface ornamented by an irregular reticulum; faint trace of tabulation
indicated by weak lines or splits in the precingular and post cingular
areas; archeopyle apical; detachment occurs along an irregular line

near the base of the apical horn.

REMARKS: Pseudoceratium turneri Cookson and Eisenack 1958 differs in having no cingulum or indication of tabulation. In the species described here ornamentation is not as elaborate as that of P. turneri. P. turneri is found in the Albian of Australia (Cookson and Eisenack 1958),

SIZE RANGE: Length 127-140 microns; width 80-86 microns; length of apical horn 26 microns; antapical horns ca. 26 microns and 14 microns. Number of specimens measured, 2.

LOCALITY OF FIGURED SPECIMENS: Pl. VII, Fig. 1: S/21/2 4/103 Southwest Potash well; depth 1165-1170 feet. Pl. VII, Fig. 3: S/21/2 17/106 Southwest Potash well; depth 1165-1170 feet. Pl. VII, Fig. 2: S/13/3 7.5/100.5 Southwest Potash well; depth 1208-1213 feet.

Genus ODONTOCHITINA Deflandre 1935

TYPE SPECIES: Odontochitina operculata (O. Wetzel) Deflandre and Cookson 1955 (= Ceratium operculata O. Wetzel 1933).

Odontochitina costata Alberti emend. Clarke and Verdier 1967

Plate VII, Figures 5,6.

For synonymy see Clarke and Verdier (1967, p. 58).

DESCRIPTION: Body outline ovoidal to subtriangular; apex conical extending into a long apical horn; apical horn slender, tapering to a point distally, expanded slightly in the mid portion with

longitudinal perforations; hypotract extends into two unequal, divergent, long antapical horns, one antapical horn in direct axial continuation with the lower part of the body, the other branching off near the equator; longitudinal perforations in the mid portions of the antapical horns are often present; body wall thin and smooth; inner body wall smooth.

REMARKS: Clarke and Verdier (1967) found that after observing several hundred specimens of O. costata and O. striatoperforata they found it difficult to differentiate these two species on the basis of the presence of perforations. They found the development of perforations to be extremely varied and irregular, in some cases confined to the distal extremity of the horns or in some more randomly disposed over the general length of the horns. Thus they consider O. striatoperforata a synonym of O. costata. The preceding evidence is accepted here.

SIZE RANGE: Overall length 411 (416) 420 microns; width of body 79 (83) 86 microns; length of apical horn 196 (241) 286 microns; length of antapical horns ca. 103 and 143 microns. Number of specimens measured, 4.

PREVIOUS RECORDS: Albian to Cenomanian of Australia (Cookson and Eisenack 1962b); lower Cenomanian of England (Cookson and Hughes 1964); Cenomanian of the Isle of Wight (Clarke and Verdier (1967); Cenomanian to Turonian of Germany (Alberti 1961); Upper Cretaceous of Canada (Manum and Cookson 1964).

LOCALITY OF FIGURED SPECIMENS: Pl. VII, Fig. 6: S/5/1 18/105.5
 Southwest Potash well; depth 1253-1258 feet. Pl. VII, Fig. 5: S/5/1
 10/102 Southwest Potash well; depth 1253-1258 feet.

Odontochitina sp. A

Plate VII, Figure 4.

DESCRIPTION: Body outline elongate, ovoidal; epitract contracts abruptly into a slender cylindrical apical horn; horn longitudinally striate with perforations; hypotract rounded, extended into two unequally developed antapical horns, one a direct axial continuation of the lower part of the body, the shorter one branching off laterally below the equator; apical archeopyle marked by a line of weakness below the apex; inner body extends to bases of antapical horns; equatorial girdle and tabulation absent; body wall thin and smooth.

SIZE RANGE: Overall length 193 microns; width 58 microns; length of apical horn 69 microns; length of antapical horns 41 microns and 54 microns. Number of specimens measured, 1.

LOCALITY OF FIGURED SPECIMEN: Pl. VII, Fig. 4: S/21/2 18/99.5
 Southwest Potash well; depth 1165-1170 feet.

Cyst-Family NETRELYTRACEAE Sarjeant and Downie 1966

Genus KALYPTEA Cookson and Eisenack 1960b

TYPE SPECIES: Kalyptea diceras Cookson and Eisenack 1960.(1960b)

REMARKS: Kalyptea is found either with or without an antapical horn; it differs from Netrelytron and Paranetrelytron in absence of an inner body.

Kalyptea monoceras Cookson and Eisenack 1960b

Plate VII, Figures 7,11.

1960b Kalyptea monoceras Cookson and Eisenack, p. 257, pl. 39, figs. 2,3.

DESCRIPTION: Body outline oval with a slender apical horn; antapex rounded; body enclosed in a thin cloak-like external membrane; body surface thin, finely granular; no apparent tabulation; cingulum or longitudinal furrow; no indication of an archeopyle.

REMARKS: Specimens are small for Kalyptea monoceras Cookson and Eisenack 1960b but have no inner body like Paranetrelytron. These specimens increase the known size range slightly for K. monoceras.

SIZE RANGE: Overall length 60 (69) 80 microns; overall width 47 (53) 66 microns; length of inner body 49 (57) 67 microns; width of inner body 34 (40) 45 microns. Number of specimens measured, 5.

PREVIOUS RECORDS: Reported from sediments of the Jurassic of Australia (Cookson and Eisenack 1960b) and in sediments ranging from Albian to Cenomanian of England (Cookson and Hughes 1964); also K. cf. monoceras has been recorded from lower Upper Cretaceous strata of Arctic Canada (Manum and Cookson 1964).

LOCALITY OF FIGURED SPECIMENS: Pl. VII, Fig. 11: S/10/1
 17.5/110 Southwest Potash well; depth 1225-1230 feet. Pl. VII,
 Fig. 7: S/16/2 9.5/112 Southwest Potash well; depth 1196-1198
 feet.

Cyst-Family STEPHODINEACEAE Eisenack emend.
 Sarjeant and Downie 1966

Genus STEPHODINIUM Deflandre 1936a

TYPE SPECIES: Stephodinium coronatum Deflandre 1936.(1936a)

Stephodinium coronatum Deflandre 1936a

Plate VI, Figure 15.

For synonymy see Clarke and Verdier (1967, p. 67).

DESCRIPTION: Body outline suboval with a surface tabulation composed of plates of varying size; equatorial girdle incompletely encircles body; girdle bordered by two flanges, extending from the shell in a plane at right angles to the longitudinal ones; ledges of the pre- and postcingular plates adjacent to the girdle run radially across the flanges to their margins; archeopyle precingular; shell membrane very thin, smooth.

REMARKS: Clarke and Verdier (1967) have found S. australicum Cookson and Eisenack 1962a and Stephodinium europaicum Cookson and Hughes 1964 to be synonymous with S. coronatum Deflandre 1936a. In the specimens recorded here no apical horn was seen and the margin of the equatorial flange is smooth and not serrate as in S. coronatum.

SIZE RANGE: Overall diameter 67 x 52 microns; diameter of inner body 23 x 29 microns. Number of specimens measured, 2.

PREVIOUS RECORDS: Stephodinium coronatum has been recorded from the upper Albian to Lower Cenomanian of England (Cookson and Hughes 1964); ?upper Albian to Cenomanian of Australia (Cookson and Eisenack 1962a); Turonian and ?Senonian of France (Deflandre 1936a, 1936b, Mercier 1938); Upper Cretaceous of Canada (Manum and Cookson 1964).

LOCALITY OF FIGURED SPECIMENS: Pl. VI, Fig. 15: S/27/1
6.5/104.5 Southwest Potash well; depth 1134-1139 feet.

Cyst-Family MEMBRANILARNACIACEAE Sarjeant and Downie 1966

Genus CHLAMYDOPHORELLA Cookson and Eisenack 1958

TYPE SPECIES: Chlamydophorella nyei Cookson and Eisenack 1958.

Chlamydophorella nyei Cookson and Eisenack 1958

Plate VII, Figures 8-10.

1958 Chlamydophorella nyei Cookson and Eisenack, p. 56, pl. 11, figs. 1,2,3.

DESCRIPTION: Body outline spherical to subspherical with a short apical projection; body covered with short simple processes which bifurcate distally and which support a delicate membrane; processes slightly longer on either side of the equatorial region

resulting in a "girdle-like" appearance of the body; no tabulation apparent; archeopyle apical.

REMARKS: Cookson and Hughes (1964) remark that most specimens of the Cambridge Greensand and those in Australia are seen in apical or antapical view; this is also true of specimens from the lower part of the Ashville Formation where Chlamydophorella nyei is a common form.

SIZE RANGE: Overall diameter 41 (50) 66 microns. Number of specimens measured, 17.

PREVIOUS RECORDS: Chlamydophorella nyei has been reported in sediments ranging from Aptian to Cenomanian in Australia (Cookson and Eisenack 1958, 1962a); in Cretaceous sediments of Graham and Ellef Ringnes Island in Canada (Manum and Cookson 1964); and in Albian to Cenomanian sediments of England (Cookson and Hughes 1964).

LOCALITY OF FIGURED SPECIMENS: Pl. VII, Fig. 10: S/27/3 6/105 Southwest Potash well; depth 1134-1139 feet. Pl. VII, Fig. 8: S/27/2 24.5/108.5 Southwest Potash well; depth 1134-1139 feet. Pl. VII, Fig. 9: S/37/3 15.5/98 Southwest Potash well; depth 1080-1085 feet.

Cysts, Classification uncertain

Genus DINOGYMNIIUM Evitt, Clarke and Verdier 1967

TYPE SPECIES: Dinogymnium acuminatum Evitt et al. 1967

REMARKS: Evitt et al. (1967) describe this form as having "tests of variable size and shape, commonly exhibiting a strong superficial similarity to motile cells of the modern genus Gymnodinium Stein; without indications of tabulation and without an inner body."

It is distinguished from Gymnodinium by the thickness, resistance, and structure of its wall and by the presence of an archeopyle (Evitt et al. 1967).

?Dinogymnium sp. A

Plate VII, Figure 12.

DESCRIPTION: Body outline subovoidal to fusiform; divided more or less equally into an epitract and a hypotract by a relatively wide cingulum bordered on both sides by a ridge; body surface ornamented by grooves and ridges, some ridges bifurcate near the equator; grooves and ridges continue across the cingulum; apex occupied by a small apical archeopyle.

REMARKS: The generic diagnosis of Evitt et al. (1967) states that the septa or other projections do not cross the cingulum but in this case they do; other features comply with the generic description. Interpretation of this form as a dinoflagellate is somewhat questionable and there is a close resemblance to some schizaeaceous spores.

SIZE RANGE: Length 84 microns; width 64 microns. Number of specimens measured, 1.

LOCALITY OF FIGURED SPECIMEN: Pl. VII, Fig. 12: S/17/1

17.5/112 Southwest Potash well; depth 1191-1196 feet.

Genus "PALEOPERIDINIUM" Deflandre 1934

TYPE SPECIES: none designated.

REMARKS: The category Paleoperidinium was designated by Deflandre (1934) to include all the dinoflagellates of the "flint" with an aspect of Peridinium of which the tabulation, although present, cannot be studied in detail. Consequently they cannot be classified with sureness into actual genera.

Because no type species was designated this genus is invalid under the rules of the International Code of Botanical Nomenclature.

Specimens allocated to this genus should be transferred to other appropriate genera.

"Paleoperidinium" cretaceum Pocock 1962

Plate VII, Figures 13-15.

1962 Paleoperidinium cretaceum Pocock, p. 80, pl. 14, figs. 219-222.

DESCRIPTION: Body outline longer than broad, pentagonal, epitract tapering to a point forming an apical horn; hypotract with two antapical horns, conical and pointed, one always longer than the other; equatorial cingulum well developed, helicoidal; longitudinal furrow present on hypotract; body wall thin and transparent, surface faintly granulate; no visible tabulation or archeopyle.

SIZE RANGE: Length 60 (81) 119 microns; width 41 (68) 88 microns; length of antapical horns 12-20 microns and 4-5 microns. Number of specimens measured, 11.

PREVIOUS RECORDS: Reported from the Cretaceous of western Canada (Pocock 1962 and Singh 1964); also found in the Senonian of Europe (in Pocock 1962).

LOCALITY OF FIGURED SPECIMENS: Pl. VII, Fig. 14: S/16/1 16/100.5 Southwest Potash well; depth 1196-1198 feet. Pl. VII, Fig. 13: S/16/3 20.5/111 Southwest Potash well; depth 1196-1198 feet. Pl. VII, Fig. 15: S/14/1 Southwest Potash well; depth 1203-1208 feet.

ANTETURMA SPORITES H. Potonié 1893

Turma TRILETES Reinsch emend. Dettmann 1963

Suprasubturma ACAVATITRILETES Dettmann 1963

Subturma AZONOTRILETES Lubert emend. Dettmann 1963

Infraturma LAEVIGATI Bennie and Kidston emend. Potonié 1956

Genus CYATHIDITES Couper 1953

TYPE SPECIES: Cyathidites australis Couper 1953.

REMARKS: Cyathidites is distinguished from Deltoidospora Miner 1935 by its concave sides and thin exine; Deltoidospora has straight to slightly convex sides and the exine is about 5 microns thick. Concavissimisporites Delcourt and Sprumont 1955 emend.

Delcourt et al. 1963 is distinguished from both the above genera by the presence of subgranulose to verrucose exine ornamentation (Singh 1964).

Cyathidites minor Couper 1953

Plate VIII, Figures 1,2.

1953 Cyathidites minor Couper p. 28, pl. 2, fig. 13.

DESCRIPTION: Trilete spore; laesurae simple, over 3/4 of the spore radius, usually gaping; equatorial outline triangular; apices broadly rounded, sides slightly concave; distal face convex; exine smooth.

SIZE RANGE: Equatorial diameter 26 (33) 44 microns. Number of specimens measured, 18.

PREVIOUS RECORDS: Lower Jurassic to Upper Cretaceous of western Canada (Pocock 1962); Lower Cretaceous Mannville Group of Alberta (Singh 1964); Joli Fou, Viking Formations and the upper shale unit of the Lower Cretaceous lower Colorado Group (Norris 1967); Albian of Oklahoma (Hedlund and Norris 1968); Jurassic to Cretaceous of Australasia (Couper 1953, Balme 1957, Dettmann 1963).

LOCALITY OF FIGURED SPECIMEN: Pl. VIII, Fig. 2: S/20/1 18.5/96 Southwest Potash well; depth 1170-1175 feet. Pl. VIII, Fig. 1: S/18/1 18.5/115 Southwest Potash well; depth 1181-1186 feet.

Genus DELTOIDOSPORA Miner emend. Potonié 1956

TYPE SPECIES: Deltoidospora hallii Miner 1935.

Deltoidospora hallii Miner 1935

Plate VIII, Figure 3.

For synonymy see Singh (1964, p. 80).

DESCRIPTION: Trilete spore; laesurae simple, gaping, extending to margin of spore; margo 3 to 4 microns wide extends from centre for 2/3 spore radius then wedges out; equatorial outline triangular, sides straight to slightly convex; apices rounded; exine laevigate and thick.

SIZE RANGE: Equatorial diameter 36 x 36 microns. Number of specimens measured, 1.

PREVIOUS RECORDS: Mesozoic sediments of western Canada (Singh 1964); Jurassic and Cretaceous of North America (Miner 1935, Pocock 1962, Brenner 1963, Singh 1964, Hedlund 1965, Norris 1967).

LOCALITY OF FIGURED SPECIMENS: Pl. VIII, Fig.3: S/30/2 19.5/101.5 Southwest Potash well; depth 1117-1123 feet.

Deltoidospora psilostoma Rouse 1959

Plate VIII, Figures 4,5.

1959 Deltoidospora psilostoma Rouse, p. 311, pl. 2, figs. 7-8.

DESCRIPTION: Trilete spore; laesurae simple, more than $\frac{2}{3}$ of spore radius; equatorial outline triangular, with well rounded apices, sides slightly convex; exine smooth to weakly punctate, relatively thick.

SIZE RANGE: Equatorial diameter 47 (55) 60 microns. Number of specimens measured, 5.

PREVIOUS RECORDS: Upper Jurassic to Upper Cretaceous of western Canada (Pocock 1962; Singh 1964). Joli Fou, Viking and upper shale units of the lower part of the Colorado Group (Norris 1967).

LOCALITY OF FIGURED SPECIMENS: Pl. VIII, Fig.5: S/13/1 9/107.5 Southwest Potash well; depth 1203-1208 feet. Pl. VIII, Fig. 6: S/21/1 19/109 Southwest Potash well; depth 1165-1170 feet.

Genus UNDULATISPORITES Pflug in Thomson and Pflug 1953

TYPE SPECIES: Undulatisporites microcutis Thompson and Pflug 1953.

Undulatisporites undulapolus Brenner 1963

Plate VIII, Figures 6,12.

1963 Undulatisporites undulapolus Brenner p. 72, pl. 24, fig. 1.

DESCRIPTION: Trilete spore; laesurae reaching the margin; commissure bordered by narrow lips; equatorial outline triangular with slightly concave to convex sides; laesurae strongly undulate for about $1/3$ to $1/2$ the spore radius; exine psilate.

REMARKS: These specimens possess a smooth exine like those described by Brenner (1963); Undulatisporites sp. cf. U. undulapolus described by Norris (1967, p. 87) differs in possessing what he terms "fossulae" on the distal face. On some specimens recorded from the lower part of the Ashville Formation the sides are slightly concave whereas those specimens described by Brenner have straight to convex sides. Brenner gives a size range of 23 (33) 43 microns on basis of 3 specimens.

SIZE RANGE: Equatorial diameter 19 (26) 33 microns. Number of specimens measured, 4.

PREVIOUS RECORDS: Potomac Group (upper Barremian to upper Albian) of Maryland (Brenner 1963); Albian of Oklahoma (Hedlund and Norris 1968). U. cf. undulapolus was reported by (Norris 1967) from the Lower Cretaceous of Alberta.

LOCALITY OF FIGURED SPECIMENS: Pl. VIII, Fig. 6: A/8/2a
8.5/99 Southwest Potash well; depth 1388-1393 feet. Pl. VIII, Fig. 12:
S/29/1 16/92.5 Southwest Potash well; depth 1123-1129 feet.

Genus STERIESPORITES Pflug 1953

TYPE SPECIES: Stereisporites steroides (Potonié and Venitz)

Pflug 1953 (Sporites stereoides Potonié and Venitz 1934).

Stereisporites antiquasporites (Wilson and Webster) Dettmann 1963

Plate VIII, Figures 7,8.

For synonymy see Dettmann (1963, p. 25).

DESCRIPTION: Trilete spore; laesurae simple, 1/2 to 2/3 of spore radius; equatorial outline sub-triangular with strongly convex sides; apices rounded; a low circular distal polar thickening; exine smooth.

SIZE RANGE: Equatorial diameter 20 (26) 29 microns. Number of specimens measured, 20.

PREVIOUS RECORDS: Known from the Upper Jurassic, Cretaceous and Tertiary of the northern and southern hemispheres; abundant in the Mannville Group (Pocock 1962, Singh 1964); persistent in the Joli Fou, Viking and upper shale units of the Lower Cretaceous of the lower Colorado Group of Alberta (Norris 1967); upper Albian Potomac Group of Maryland (Brenner 1963); and ?Cenomanian of Australia (Dettmann 1963).

LOCALITY OF FIGURED SPECIMENS: Pl. VIII, Fig. 8: S/29/1 5/107 Southwest Potash well; depth 1123-1129 feet. Pl. VIII, Fig. 7: S/18/2 19/98 Southwest Potash well; depth 1186-1191 feet.

Infraturma APICULATI Bennie and Kidston emend. Potonié 1956

Genus CONCAVISSIMISPORITES Delcourt and Sprumont emend. Singh 1964

TYPE SPECIES: Concavissimisporites verrucosus Delcourt and Sprumont 1955.

REMARKS: Singh (1964) emended the revised diagnosis of Delcourt et al. (1963) to include subgranulose and granulose spores as he felt the genus should not be restricted to include only verrucose spores as proposed by Delcourt et al. (1963).

Concavissimisporites granulatus Pocock 1965

Plate 8, Figure 9.

1965 Concavissimisporites granulatus Pocock, p. 184, pl. 5, figs. 11-12.

DESCRIPTION: Trilete spore; laesurae extending almost to margin of spore; commissures bordered by narrow lips; equatorial outline triangular, sides slightly concave; apices rounded; exine about 2 microns thick, ornamented with faint granules proximally and distally.

REMARKS: This specimen is smaller than those described by Pocock 48 (53) 58 microns.

SIZE RANGE: Equatorial diameter 42 x 52 microns. Number of specimens measured, 1.

PREVIOUS RECORDS: Uppermost part of the upper Mannville Group (middle Albian) of Saskatchewan (Pocock 1965).

LOCALITY OF FIGURED SPECIMEN: Pl. VIII, Fig. 9: S/12/2
20/104 Southwest Potash well; depth 1213-1220 feet.

Concavissimisporites punctatus (Delcourt and Sprumont) Singh 1964

Plate VIII, Figure 10.

For synonymy see Singh (1964, p. 77).

DESCRIPTION: Trilete spore; laesurae extending $3/4$ of spore radius; margo bordering laesurae, narrowing sharply towards the ends; equatorial outline triangular, sides concave to almost straight, apices well rounded; both distal and proximal surfaces have an undulose appearance.

SIZE RANGE: Equatorial diameter 55 (65) 74 microns. Number of specimens measured, 3.

PREVIOUS RECORDS: Upper Mannville Group (Singh 1964); lower part of the Colorado Group (Norris 1967), Berriasian of England (Couper 1958) and "Wealden" of Belgium (Delcourt and Sprumont 1955).

LOCALITY OF FIGURED SPECIMENS: Pl. VIII, Fig. 10: S/3/1
18.5/108 Southwest Potash well; depth 1263-1268 feet.

Concavissimisporites verrucosus (Delcourt and Sprumont) Pocock
var. minor Pocock 1962

Plate VIII, Figure 11.

1962 Concavissimisporites verrucosus (Delcourt and Sprumont)
var. minor Pocock, p. 47, pl. 5, fig. 75.

DESCRIPTION: Trilete spore; laesurae about 3/4 of spore radius, margo indistinct, obscured by surface ornament; equatorial outline triangular with concave sides; apices broadly rounded; proximal and distal exine ornamented with large granules about 1.5 to 2 microns at the base and up to 2 microns in height.

REMARKS: This form is similar to Concavissimisporites variverrucatus (Couper) Singh 1964 but the ornamentation is composed of distinct granules as opposed to the verrucate ornamentation of C. variverrucatus.

SIZE RANGE: Equatorial diameter 47 x 52 microns. Number of specimens measured, 1.

PREVIOUS RECORDS: Lower Mannville Group (Barremian) of western Canada (Pocock 1962).

LOCALITY OF FIGURED SPECIMEN: Pl. VIII, Fig. 11: A/9/1 14/103 Alwinal well; depth 1383-1388 feet.

Genus OSMUNDACIDITES Couper 1953

TYPE SPECIES: Osmundacidites wellmanii Couper 1953.

Osmundacidites wellmanii Couper 1953

Plate VIII, Figures 13-15.

For synonymy see Norris (1967, p. 88).

DESCRIPTION: Trilete spore; laesurae simple, at least 3/4 of spore radius; equatorial contour circular but frequently folded; exine ornamented with granulate sculpture.

REMARKS: Osmundacidites possesses a granular to papillate sculpture in contrast to Baculatisporites which has baculate ornamentation.

SIZE RANGE: Equatorial diameter 39 (47) 56 microns. Number of specimens measured, 6.

PREVIOUS RECORDS: Reported from Jurassic and Lower Cretaceous sediments in the northern and southern hemispheres; Lower Cretaceous Mannville Group of Alberta (Singh 1964); (Norris 1967) reported it in all units of the Lower Cretaceous lower part of the Colorado Group of Alberta.

LOCALITY OF FIGURED SPECIMENS: Pl. VIII, Fig. 13: A/14/2 9.5/92.5 Alwinsal well; depth 1358-1363 feet. Pl. VII, Fig. 15: S/11/3 4/99 Southwest Potash well; depth 1220-1225 feet. Pl. VIII, Fig. 14: A/17/2 15/112.5 Alwinsal well; depth 1338-1343 feet.

Genus BACULATISPORITES Thomson and Pflug 1953

TYPE SPECIES: Baculatisporites primarius (Wolff) Thomson and Pflug 1953 (= Sporites primarius Wolff 1934).

Baculatisporites cf. B. comaumensis (Cookson) Potonié 1956

Plate VIII, Figure 16.

For synonymy see Norris (1967, p. 88).

DESCRIPTION: Trilete spore; laesurae simple and straight; equatorial outline suboval; surface baculate, bacula up to 15 microns above surface.

REMARKS: Osmundacidites wellmanii differs in having a thinner body wall and in having granular and papillate ornamentation. These specimens extend the size range.

SIZE RANGE: Equatorial diameter 39 (53) 68 microns. Number of specimens measured, 7.

PREVIOUS RECORDS: Upper Triassic of Europe (Klaus 1960); pre Tertiary Comaum Clay of South Australia (Cookson 1953); Jurassic and Cretaceous of Australia (Dettmann 1963); Albian or lower to middle Kimmeridgian strata of New Zealand (Norris 1968); Lower Cretaceous lower part of the Colorado Group of Alberta (Norris 1967); and Albian of Oklahoma (Hedlund and Norris 1968).

LOCALITY OF FIGURED SPECIMEN: Pl. VIII, Fig. 16: S/13/1
19.5/107.5 Southwest Potash well; depth 1208-1213 feet.

Genus ACANTHOTRILETES Naumova emend. Potonié and Kremp 1954

TYPE SPECIES: Acanthotriletes ciliatus (Knox) Potonié and Kremp 1954 (= Spinoso-sporites ciliatus Knox 1950).

Acanthotriletes varispinosus Pocock 1962

Plate VIII, Figures 17-20.

1962 Acanthotriletes varispinosus Pocock, p. 36, pl. 1, figs. 18-20

For synonymy see Norris (1967, p. 89).

DESCRIPTION: Trilete spore; laesurae about $3/4$ of spore radius; equatorial outline subcircular; proximal surface scabrate; distal surface spinose, spines pointed, about 6 microns long, base 1 to 4 microns wide.

SIZE RANGE: Equatorial diameter 22 (33) 41 microns. Number of specimens measured, 6.

PREVIOUS RECORDS: Lower Cretaceous (?Berriasian) of England, Lower Cretaceous Mannville Group of Alberta and the Lower Cretaceous Joli Fou, Viking and upper shale unit of the lower part of the Colorado Group of Alberta (Norris 1967).

LOCALITY OF FIGURED SPECIMENS: Pl. VIII, Fig. 20: S/44/1 22/102 Southwest Potash well; depth 1035-1040 feet. Pl. VIII, Fig. 17: A/8/2a 17/93 Alwinsal well; depth 1388-1393 feet. Pl. VIII, Fig. 18: A/12/1 14/98.5 Alwinsal well; depth 1368-1373 feet. Pl. VIII, Fig. 19: S/36/1 7.5/95.5 Southwest Potash well; depth 1085-1090 feet.

Genus PILOSPORITES Delcourt and Sprumont 1955

TYPE SPECIES: Pilosporites trichopapillosus (Thiergart)

Delcourt and Sprumont 1955 (= Sporites trichopapillosus Thiergart 1949).

Pilosisorites sp. Norris 1967

Plate VIII, Figures 21,22.

1967 Pilosisorites sp. Norris, p. 89, pl. 10, fig. 23.

DESCRIPTION: Trilete spore; laesurae long, simple, extending to the equator; equatorial outline triangular with slightly concave sides; proximal and distal sides covered with echinate and papillate; projections 0.5 microns to 1 micron in basal diameter, 0.5 microns to 2 microns high.

REMARKS: Pilosisorites brevipapillosus Couper is characterized by entirely papillate ornament. Specimens found by Norris (1967, p. 89) and specimens of P. brevipapillosus of Brenner (1963, p. 67) show echinate and papillate ornamentation as do specimens described here. Some specimens do not show interradian thickening. Norris gives a size range of 25 - 31 microns.

SIZE RANGE: Equatorial diameter 24 (30) 37 microns. Number of specimens measured, 7.

PREVIOUS RECORDS: Upper part of the Patapsco Formation (late Albian) of Maryland (Brenner 1963); Viking and upper shale of the lower part of the Lower Cretaceous Colorado Group of Alberta (Norris 1967).

LOCALITY OF FIGURED SPECIMENS: Pl. VIII, Fig. 22: S/11/2 11/111 Southwest Potash well; depth 1220-1225 feet. Pl. VIII, Fig. 21: A/10/1a 5/102.5 Alwinal well; depth 1398-1383 feet.

Genus APICULATISPORIS Potonié and Kremp 1956

TYPE SPECIES: Apiculatisporis aculeatus (Ibrahim) Potonié 1956
(Apiculatisporites aculeatus Ibrahim 1933).

Apiculatisporis babsae Brenner 1963

Plate VIII, Figure 27.

1963 Apiculatisporis babsae Brenner, p. 56, pl. 13, figs. 2,3.

DESCRIPTION: Trilete spore; laesurae simple, $3/4$ radius of spore; equatorial outline triangular with acute corners; sides straight to slightly convex; exine ornamented by coni up to 6 microns high and about 3 to 4 microns wide at the basal end; coni about 2 microns apart.

SIZE RANGE: Equatorial diameter 39×41 microns. Number of specimens measured, 1.

PREVIOUS RECORDS: Apiculatisporis babsae was reported from the Albian Patapsco Formation of Maryland (Brenner 1963).

LOCALITY OF FIGURED SPECIMEN: Pl. VIII, Fig. 27: A/17/2
8.5/111 Alwinal well; depth 1338-1343 feet.

Genus NEORAISTRICKIA Potonié 1956

TYPE SPECIES: Neoraistrickia truncata (Cookson) Potonié 1956
(=Triletes truncatus Cookson 1953).

Neoraistrickia truncata (Cookson) Potonié 1956

Plate VIII, Figure 23.

For synonymy see Norris (1967, p. 89).

DESCRIPTION: Trilete spore; laesurae undulose extending to equator, commissures raised, about 1 microns wide; equatorial outline rounded triangular; both proximal and distal sides ornamented with short broadly based truncate processes ca. 1.5 microns wide and 1.5 microns high.

SIZE RANGE: Equatorial diameter (including spines) 30 (33) 34 microns. Number of specimens measured, 6.

PREVIOUS RECORDS: Upper Jurassic and Lower Cretaceous of western Canada (Pocock 1962); Viking and upper shale units of the lower part of the Colorado Group of Alberta (Norris 1967); pre-Tertiary clays of Comaun, South Australia (Cookson 1953).

LOCALITY OF FIGURED SPECIMEN: Pl. VIII, Fig. 23: A/17/1 10.5/106 Alwinal well; depth 1338-1343 feet.

Infraturma MURORNATI Potonié and Kremp 1954

Genus LYCOPODIUMSPORITES Thiergart ex Delcourt and Sprumont 1955

TYPE SPECIES: Lycopodiumsporites agathoecus (Potonié)

Thiergart 1938 (= Sporites agathoecus Potonié 1934).

Lycopodiumsporites austroclavatidites (Cookson) Potonié 1956

Plate VIII, Figure 26.

For synonymy see Pocock (1962, p. 33).

DESCRIPTION: Trilete spore; laesurae straight, extending 3/4 to full length of spore radius; equatorial outline sub-rounded to convexly triangular; exine smooth on the proximal surface; coarsely reticulate on the distal surface; lumina of reticulum about 8 microns, lumina extend beyond edge of spore forming a thin membranous flange-like zone around the equator.

REMARKS: The size range given by Cookson (1953) is 37-48 microns.

SIZE RANGE: Equatorial diameter 34 (44) 51 microns. Number of specimens measured, 2.

PREVIOUS RECORDS: Lower Cretaceous of Alberta (Singh 1964); from the Santonian of Sweden (Ross 1949); pre-Tertiary clays of Comaun, South Australia (Cookson 1953); upper Albian Patapsco of Maryland (Brenner 1963) Mannville Group and Lower Cretaceous of the lower part of the Colorado Group (Norris 1967).

LOCALITY OF FIGURED SPECIMEN: Pl. VIII, Fig. 26: A/17/3 11/102.5 Alwinal well; depth 1338-1343 feet.

Lycopodiumsporites marginatus Singh 1964

Plate VIII, Figure 24.

1964 Lycopodiumsporites marginatus Singh, p. 41, pl. 1, figs. 7-10.

DESCRIPTION: Trilete spore; laesurae extending $3/4$ of spore radius or more; commissures raised; equatorial outline rounded - triangular with strongly convex sides; proximal surface laevigate with three membraneous tangentially arranged muri (one on each inter-radial area) approximately midway between the proximal pole and equator; distal surface reticulate with large polygonal lumina 7-13 microns in diameter.

SIZE RANGE: Equatorial diameter 41 (45) 51 microns. Number of specimens measured, 2.

PREVIOUS RECORDS: Aptian to Albian or Cenomanian of Alberta (Singh 1964, Norris 1967); Albian of Oklahoma (Hedlund and Norris 1968).

LOCALITY OF FIGURED SPECIMENS: Pl. VIII, Fig. 24: S/13/1
14/99 Southwest Potash well; depth 1208-1213 feet.

Lycopodiumsporites reticulumsporites (Rouse) Dettmann 1963

Plate VIII, Figure 25.

For synonymy see Dettmann (1963, p. 45).

DESCRIPTION: Trilete spore; laesurae straight extending to the margin; equatorial outline circular to convexly triangular; exine

reticulate; distal and equatorial reticulum; muri low, straight sided, usually coalesce to enclose hexagonal or pentagonal lumina 3 - 6 microns in diameter; proximal surface with reduced sculpture of low, radially elongate muri.

SIZE RANGE: Equatorial diameter 33 (36) 39 microns. Number of specimens measured, 2.

PREVIOUS RECORDS: Bathonian of England (Lantz 1958); probable Upper Jurassic of southeast British Columbia (Rouse 1959); Lower Cretaceous of Australia (Dettmann 1963); rare in the Lower Cretaceous lower part of the Colorado Group of Alberta (Norris 1967).

LOCALITY OF FIGURED SPECIMEN: Pl. VIII, Fig. 25: S/16/3 17/97 Southwest Potash well; depth 1196-1198 feet.

Genus TIGRISPORITES Klaus 1960

TYPE SPECIES: Tigrisporites halleinis Klaus 1960.

Tigrisporites scurrandus Norris 1967

Plate VIII, Figures 28,29.

1967 Tigrisporites scurrandus Norris, p. 91, pl. 11, figs. 3-7.

DESCRIPTION: Trilete spore; equatorial outline triangular with rounded angles and straight to slightly convex sides; laesurae long, raised, lips 0.5 microns to 1 micron wide; distal surface with a polar crassitude irregularly rounded in shape with a crenulate margin, extending about one half the equatorial diameter at its maximum extent,

sinuous rugulae cover the remainder of the distal face; proximal surface mainly laevigate with occasional granules.

SIZE RANGE: Equatorial diameter 23 (34) 41 microns. Number of specimens measured, 2.

PREVIOUS RECORDS: Upper part of the Joli Fou, Viking and upper shale units of the Lower Cretaceous lower part of the Colorado Group of Alberta (Norris 1967).

LOCALITY OF FIGURED SPECIMENS: Pl. VIII, Fig. 29: S/14/1 8.5/102 Southwest Potash well; depth 1203-1208 feet. Pl. VIII, Fig. 28: S/10/2 3/109 Southwest Potash well; depth 1225-1230 feet.

Genus TAUCUSPORITES Stover 1962 emend. Playford and Dettmann 1965

TYPE SPECIES: Taurocusporites segmentatus Stover 1962.

REMARKS: Playford and Dettmann (1965) restricted the generic diagnosis to include forms that are only proximally sculptured, which in other (distal) respects are close to Polycingulatisporites Simoncsics and Kedves 1961.

Taurocusporites segmentatus Stover 1962

Plate VIII, Figure 30.

1962 Taurocusporites segmentatus Stover, p. 56, pl. 1, figs. 1-14.

DESCRIPTION: Trilete spore; laesurae extending to the equator, raised slightly; equatorial outline rounded-triangular with a smooth

to crenulate margin; sides straight to convex; apices rounded; three concentric thickened ring-like ridges surrounding a distal polar thickening; proximal exine sculptured with indistinct irregularly shaped rugulae.

REMARKS: Staplinisporites Pocock 1962 differs in that it has both radially and concentrically arranged distal thickenings. The spore wall is cracked as Stover has frequently found with Maryland specimens.

SIZE RANGE: Equatorial diameter 52 x 49 microns. Number of specimens measured, 1.

PREVIOUS RECORDS: Lower Cretaceous of Maryland (Stover 1962) and Lower Cretaceous Mannville Group of Alberta (Singh 1964).

LOCALITY OF FIGURED SPECIMENS: Pl. VIII, Fig. 30: A/17/1 9/101.5 Alwinal well; depth 1338-1343 feet.

Genus RETICULISPORITES Potonié and Kremp in
Weyland and Krieger 1953

TYPE SPECIES: Reticulisporites parvogranulatus Weyland and Krieger 1953.

Reticulisporites sp. Norris 1967

Plate VIII, Figure 34.

1967 Reticulisporites sp. Norris, p. 91, pl. 11, figs. 10, 11.

DESCRIPTION: Trilete spore; equatorial outline triangular with broadly rounded apices and straight to slightly concave sides; laesurae straight extending almost to margin; proximal surface laevigate; distal surface with imperfect reticulum, lumina angular, polyhedral 3 - 5 microns; muri 0.5 microns or less and about 1 micron high.

SIZE RANGE: Equatorial diameter 30 (35) 37 microns. Number of specimens measured, 5.

PREVIOUS RECORDS: Upper shale unit of the lower part of the Lower Cretaceous Colorado Group of Alberta (Norris 1967).

LOCALITY OF FIGURED SPECIMEN: Pl. VIII, Fig. 34: A/8/2a 17/108 Alwinal well; depth 1388-1393 feet.

Genus *CICATRICOSISPORITES* Potonié and Gelletich 1933

TYPE SPECIES: Cicatricosisporites dorogensis Potonié and Gelletich 1933.

Cicatricosisporites hallei Delcourt and Sprumont 1955

Plate VIII, Figures 31-33, 35, 36.

For synonymy see Norris (1967, p. 92).

DESCRIPTION: Trilete spore; equatorial outline rounded-triangular; sides convex; apices rounded; exine ornamented with fine ribs, superposition of the ribs of proximal and distal sides forms a rhombic net-like pattern.

REMARKS: The size range given in the description of the type species is a maximum diameter of 35 (40) 57 microns. Specimens recovered from the Ashville, like those recovered by Norris 1967 are smaller. "Pelleteria" minutaestriata Bolkohovitina (1961) is similar but is larger.

SIZE RANGE: Equatorial diameter 26 (33) 45 microns. Number of specimens measured, 21.

PREVIOUS RECORDS. Lower Cretaceous of Belgium, England, Maryland and Alberta (Delcourt and Sprumont 1955, Couper 1958; Brenner 1963; Singh 1964); Lower Cretaceous Mannville Group and Lower Cretaceous lower part of the Colorado Group of Alberta (Norris 1967); Albian of Oklahoma (Hedlund and Norris 1968).

LOCALITY OF FIGURED SPECIMENS: Pl. VIII, Fig. 33: S/12/1 13/96.5 Southwest Potash well; depth 1213-1220 feet. Pl. VIII, Fig. 35: A/9/3 15/100 Alwinal well; depth 1383-1388 feet. Pl. VIII, Fig. 32: S/11/2 8.5/98 Southwest Potash well; depth 1220-1225 feet. Pl. VIII, Fig. 31: S/11/1 15/97 Southwest Potash well; depth 1208-1213 feet.

Cicatricosisporites hughesi Dettmann 1963

Plate VIII, Figures 39,40.

1963 Cicatricosisporites hughesi Dettmann, p. 55, pl. 10, figs. 6-16.

DESCRIPTION: Trilete spore; laesurae simple slits, straight; equatorial outline triangular, sides slightly convex; apices angular;

proximal exine ornamented by muri 2 - 3 microns wide and 3 - 4 microns high; separated by lumina 4 - 6 microns wide, muri sinuous, parallel to sides of spore coalescing along the bisectors of the apical angles.

REMARKS: For other specimens that may be conspecific with Cicatricosisporites hughesi see Dettmann (1963, p. 55). Appendicisporites potomacensis Brenner 1963 has distinctly developed appendices and is smaller.

SIZE RANGE: Equatorial diameter 60 x 64 microns. Number of specimens measured, 1.

PREVIOUS RECORDS: Aptian, Albian and ?Cenomanian of Australia and possibly Lower Cretaceous strata of England and Russia; Lower Cretaceous and Cenomanian of the United States according to Dettmann (1963). Norris (1967) reported it from the lower part of the Colorado Group of Alberta.

LOCALITY OF FIGURED SPECIMEN: Pl. VIII, Figs. 39,40: S/43/1 8/107 Southwest Potash well; depth 1040-1045 feet.

Cicatricosisporites perforatus (Baranov et al.) Singh 1964

Plate VIII, Figures 37,38,41.

For synonymy see Singh (1964, p. 58).

DESCRIPTION: Trilete spore; laesurae straight, extending to margin, commissures raised; equatorial outline triangular, sides convex, apices rounded; proximal surface ornamented by 5 sets of ribs

3 - 5 microns wide, spaced about 1 micron apart running parallel to the sides of the spore, extending to the equator; distal surface ornamented by about 9 ribs, 2 - 3 microns wide, spaced about 1 micron apart, disposed obliquely to one side of the spore from the opposite apex, muri merge at the apices, muri ornamented by a single row of perforations in both distal and proximal surfaces, perforations about 1/2 micron in diameter and 1.5 to 2 microns apart.

REMARKS: The size range of these specimens falls between the size range stated by Singh (1964) (48 to 58 microns) and the size range of Russian specimens stated by Baranov et al. (1959) (35.5 to 36.8 microns). This presents some evidence that the two previously known ranges may represent a continuous size range.

SIZE RANGE: Equatorial diameter 37 (50) 56 microns. Number of specimens measured, 5.

PREVIOUS RECORDS: Mannville Group and Colorado Group (Lower Cretaceous) of western Canada (Pocock 1962, Singh 1964); Aptian to Turonian of the U.S.S.R. (Baranov et al. 1959).

LOCALITY OF FIGURED SPECIMENS: Pl. VIII, Fig. 41: A/17/1 10.5/94 Alwinal well; depth 1338-1343 feet. Pl. VIII, Figs. 37,38: S/43/1 7/103 Southwest Potash well; depth 1040-1045 feet.

Cicatricosisporites sp. Singh 1964

Plate VIII, Figure 42.

For synonymy see Norris (1967, P. 93)

DESCRIPTION: Trilete spore; laesurae long, straight, reaching the equator, often torn along laesurae; body outline triangular with crenulate margin formed by ribs; ribs sub parallel to outline on proximal side and oblique on other.

SIZE RANGE: Equatorial diameter 56 microns. Number of specimens measured, 1.

PREVIOUS RECORDS: Lower Cretaceous from the upper Mannville Group of western Canada (Singh 1964) and the lower part of the Colorado Group of western Canada (Norris 1967).

LOCALITY OF FIGURED SPECIMEN: Pl. VIII, Fig. 42: S/14/1 9.5/94.5 Southwest Potash well; depth 1203-1208 feet.

Cicatricosisporites sp. Norris 1967

Plate IX, Figure 1.

For synonymy see Norris (1967, p. 93).

DESCRIPTION: Trilete spore; equatorial outline triangular with rounded apices and straight to convex sides; laesurae about 3/4 of spore radius, simple; proximal surface ornamented with 6 or 7 sets of muri, each 3 - 4 microns wide, continuing around the apices; distal surface ornamented with muri, outer 3-4 sets parallel to outline of spore, muri 3-4 microns wide.

SIZE RANGE: Equatorial diameter 68 microns. Number of specimens measured, 1.

PREVIOUS RECORDS: Lower Cretaceous upper Mannville Group of western Canada (Singh 1964) and the Lower Cretaceous lower part of the Colorado Group of Alberta (Norris 1967).

LOCALITY OF FIGURED SPECIMEN: Pl. IX, Fig. 1: S/6/1 17/114 Southwest Potash well; depth 1249-1253 feet.

Cicatricosisporites sp. A

Plate IX, Figure 2.

DESCRIPTION: Trilete spore; laesurae simple, about 3/4 of spore radius, equatorial outline triangular with broadly rounded apices and straight to convex sides; surface ornamented with fine muri about 0.5 microns wide, muri with sharply rounded tops, spaced 1-1.5 microns apart.

SIZE RANGE: Maximum diameter 60 microns. Number of specimens measured, 1.

LOCALITY OF FIGURED SPECIMEN: Pl. 9, Fig. 2: S/44/3 6.5/106 Southwest Potash well; depth 1035-1040 feet.

Subturma ZONOTRILETES Waltz 1935

Infraturma AURICULATI Schopf emend. Dettmann 1963

Genus APPENDICISPORITES Weyland and Krieger 1953

TYPE SPECIES: Appendicisporites tricuspidatus Weyland and Greifeld 1953.

Appendicisporites symskiensis (Markova) n. comb.

Plate IX, Figure 9.

1961 Anemia symskiensis Markova in Samoilovitch et al., p. 81,
pl. 21, fig. 3a.

DESCRIPTION: Trilete spore; laesurae indistinct, probably reaching apices; equatorial outline triangular, sides concave; apices large, globular; exine ornamented by numerous fine muri which extend parallel to the sides of the spore on the distal surface; muri fold around the apices onto the proximal surface where they wedge out obliquely against the laesurae, muri ornamented by small granules.

SIZE RANGE: Equatorial diameter 67 x 89 microns. Number of specimens measured, 1.

PREVIOUS RECORDS: Middle Cretaceous, Cenomanian of western Siberia (Samoilovitch et al. 1961).

LOCALITY OF FIGURED SPECIMEN: Pl. IV, Fig. 9: S/3/1 6/102 Southwest Potash well; depth 1263-1268 feet.

Appendicisporites tricornitatus Weyland and Greifeld 1953

Plate IX, Figures 7,8.

1953 Appendicisporites tricornitatus Weyland and Greifeld, p. 43,
pl. 11, fig. 52.

DESCRIPTION: Spore trilete; laesurae long, reaching almost to the equator; equatorial outline more or less triangular with straight to slightly convex sides and rounded angles prolonged as appendices about 4 microns long; proximal surface laevigate except for one triangular set of muri close to the equator and parallel to the equatorial outline; distal surface laevigate with 3 or 4 triangular sets of muri parallel to the margin; muri 2-4 microns wide; proximal side with 2 or 3 sets of muri prolonged into appendices at the angles.

SIZE RANGE: Equatorial diameter 39 (43) 48 microns. Number of specimens measured, 4.

PREVIOUS RECORDS: Cretaceous. Abundant in the Mannville Group of Alberta (Singh 1964), lower Senonian of Germany (Weyland and Greifeld 1953); appears first at the top of the Berriasian in Europe (Hughes 1958).

LOCALITY OF FIGURED SPECIMENS: Pl. IX, Fig. 7: A/10/1 14.5/110 Alwinal well; depth 1378-1383 feet. Pl. IX, Fig. 8: A/17/1 13/106 Alwinal well; depth 1338-1343 feet.

Appendicisporites unicus (Markova) Singh 1964

Plate IX, Figure 5.

For synonymy see Singh (1964, p. 53).

DESCRIPTION: Trilete spore; laesurae almost to margin of spore, commissures raised; equatorial outline triangular; exine laevigate;

sides straight to convex; distal face ornamented by about 3 muri parallel to the sides of the spore; proximal face about 2 muri parallel to the sides of the spore.

SIZE RANGE: Equatorial diameter 44-48 microns. Number of specimens measured, 2.

PREVIOUS RECORDS: Albian of Alberta; Cenomanian of Siberia (Samoilovitch et al. 1961); Grand Rapids Formation of Alberta (Singh 1964) and upper shale unit of the lower part of the Colorado Group (Norris 1967).

LOCALITY OF FIGURED SPECIMEN: Pl. IX, Fig. 5: S/16/3 20/98 Southwest Potash well; depth 1196-1198 feet.

Appendicisporites sp. A

Plate IX, Figures 3,4.

DESCRIPTION: Trilete spore; laesurae simple slits, extending about 1/2 spore radius; equatorial outline subtriangular; apices well rounded; proximal exine ornamented by 3 to 5 micron wide ribs, with 3 ribs in each interapical area, parallel to the equatorial outline; distal face ornamented by a series of parallel ribs 5 microns wide separated by furrows about 1 micron wide and disposed obliquely to one side of the spore from the opposite apex, these distal ribs merging with the equatorial zone.

REMARKS: The proximal ridges continue around the apices onto the distal surface.

SIZE RANGE: Equatorial diameter 44 x 57 μ . Number of specimens measured, 1.

LOCALITY OF FIGURED SPECIMEN: S/7/3 20.5/107 Southwest Potash well; depth 1240-1245 feet.

Infraturma TRICRASSATI Dettmann 1963

Genus GLEICHENIIDITES Ross ex Delcourt & Sprumont emend.
Dettmann 1963

TYPE SPECIES: Gleicheniidites senonicus Ross 1949.

Gleicheniidites apilobatus Brenner 1963

Plate IX, Figures 14,15.

1963 Gleicheniidites apilobatus Brenner, p. 52, pl. 11, figs. 2-3.

1964 Gleicheniidites cf. G. circinidites (Cookson) Singh, p. 69, pl. 8, figs. 10,11.

DESCRIPTION: Trilete spore; laesurae bordered by a thin margo, reaching to the equator; equatorial outline broadly triangular; apices pointed and rhombic in shape; sides slightly concave; on distal side a ridge crosses the apical lobe at its greatest width, probably due to folding; apical ridges connected by continued ridge development along the distal side close to the equator; exine smooth.

REMARKS: Gleicheniidites cf. G. circinidites (Cookson) Singh 1964 appears synonymous with Gleicheniidites apilobatus (Brenner, 1963).

This form resembles Deltoidospora juncta (Singh 1964) but laesurae do not reach the margin and sides are not strongly concave.

SIZE RANGE: Equatorial diameter 28 x 28 microns. Number of specimens measured, 2.

PREVIOUS RECORDS: Recorded from the Albian Potomac Group of Maryland (Brenner 1963).

LOCALITY OF FIGURED SPECIMENS: Pl. IX, Fig. 14: S/30/1 8.5/96.5 Southwest Potash well; depth 1117-1123 feet. Pl. IX, Fig. 15: A/8/1a 10/101 Alwinal well; depth 1388-1393 feet.

Gleicheniidites senonicus Ross ex Delcourt and Sprumont 1955
Plate IX, Figures 6,10.

For synonymy see Singh (1964, p. 69).

DESCRIPTION: Trilete spore; laesurae simple, extending to the equator; equatorial outline triangular; apices acute; sides straight to concave; proximo-distal flattening resulting in three folds on distal side parallel to outer margin of spore; exine smooth.

SIZE RANGE: Equatorial diameter 20 (29) 39 microns. Number of specimens measured, 23.

PREVIOUS RECORDS: Middle Jurassic to Upper Cretaceous in the northern hemisphere (Norris 1967).

LOCALITY OF FIGURED SPECIMENS: Pl. IX, Fig. 6: A/10/3 3/100.5 Alwinal well; depth 1378-1383 feet. Pl. IX, Fig. 10: S/27/3 8/105.5 Southwest Potash well; depth 1134-1139 feet.

Genus PUNCTATRILETES Pierce 1961

TYPE SPECIES: Punctatriletes magnimundus Pierce 1961.

Punctatriletes parvimundus Pierce 1961

Plate IX, Figure 11.

1961 Punctatriletes parvimundus Pierce, p. 28, pl. 1, fig. 13.

DESCRIPTION: Trilete spore; laesurae straight, simple slits, extending to the equator; equatorial outline triangular; interr radial crassitudes; exine punctate.

REMARKS: Though interr radial thickening is not mentioned in Pierce's description it is apparent on the figured specimen and corresponds to those seen in these specimens.

SIZE RANGE: Equatorial diameter 22 (30) 37 microns. Number of specimens measured, 11.

PREVIOUS RECORDS: Upper Cretaceous (?Cenomanian) of Minnesota (Pierce 1961).

LOCALITY OF FIGURED SPECIMEN: Pl. 9, Fig. 11: S/16/3
17.5/96.5 Southwest Potash well; depth 1196-1198 feet.

Genus SESTROSPORITES Dettmann 1963

TYPE SPECIES: Sestrosporites irregulatus (Couper) Dettmann
1963 (= Foveotrilletes irregulatus Couper 1958).

Sestrosporites cf. S. pseudoalveolatus (Couper) Dettmann 1963

Plate IX, Figure 12.

DESCRIPTION: Trilete spore; laesurae extending to the equator, commissures simple slits; sides convex; proximal surface granulate; equatorial exine differentially thickened in interradianal regions where crassitudes are developed; in compressed specimens a membranous equatorial "zona" formed; exine sculptured with deep foveolae.

REMARKS: Dettmann (1963, p. 66) has shown that the zona is a feature induced by compression and/or prolonged maceration which results from rupture of the interradianal crassitudes.

SIZE RANGE: Equatorial diameter 47 (51) 54 microns. Number of specimens measured, 2.

PREVIOUS RECORDS: Aptian to lower Albian of Alberta (Singh 1964); Bajocian to Aptian of Britain (Couper 1958); Lower Cretaceous of Australia (Dettmann 1963) and the Lower Cretaceous lower part of the Colorado Group of Alberta (Norris 1967).

LOCALITY OF FIGURED SPECIMEN: Pl. IX, Fig. 12: A/8/2a
18.5/102 Alwinal well; depth 1388-1393 feet.

Genus CORONATISPORA Dettmann 1963

TYPE SPECIES: Coronatispora perforata Dettmann 1963.

Coronatispora valdensis (Couper) Dettmann 1963

Plate IX, Figure 13.

For synonymy see Norris (1967, p. 96).

DESCRIPTION: Trilete spore; laesurae extending to the equator, commissures raised; equatorial outline rounded triangular; proximal surface smooth, with scattered granules; distal surface with two concentric bands of thickened exine, outer band separated from cingulum by a 5 micron wide zone, inner thickening surrounding the distal pole.

REMARKS: Singh (1964, p. 85) remarks that the distal pole possesses a thickened granulose boss which may become detached leaving a thin granulose area exposed. The feature is recognizable on the specimen figured here.

SIZE RANGE: Equatorial diameter 43 x 45 microns. Number of specimens measured, 1.

PREVIOUS RECORDS: Upper Jurassic of England (Lantz 1958, Norris 1963); Wealden and Aptian of England (Couper 1958); Lower Cretaceous of western Canada (Pocock 1962, Singh 1964); Albian of Maryland (Brenner 1963); Norris (1967) recovered one specimen from the upper shale unit of the Lower Cretaceous lower part of the Colorado Group of Alberta.

LOCALITY OF FIGURED SPECIMEN: Pl. IX, Fig. 13: S/17/3
10.5./110 Southwest Potash well; depth 1191-1196 feet.

Genus CAMAROZONOSPORITES Pant ex Potonié emend. Klaus 1960

TYPE SPECIES: Camarozonosporites cretaceous (Weyland and Krieger) Potonié 1956.

REMARKS: The emended diagnosis of Klaus describes the genus as rugulate distally and with reduced proximal sculpture.

Camarozonosporites insignis Norris 1967

Plate IX, Figures 19-21,26,27.

For synonymy see Norris (1967, p. 96).

DESCRIPTION: Spore trilete; laesurae simple, straight, extending $3/4$ of spore radius, often folded back; proximal surface with low indistinct rugulae; distal surface ornamented with thicker branching rugulae; interradianal crassitudes 3-4 microns wide at the equator.

SIZE RANGE: Equatorial diameter 30 (37) 52 microns. Number of specimens measured, 12.

PREVIOUS RECORDS: Albian of Maryland (Brenner 1963); Viking and upper shale units of the Lower Cretaceous lower part of the Colorado Group of Alberta (Norris 1967); and Albian of Oklahoma (Hedlund and Norris 1968).

LOCALITY OF FIGURED SPECIMENS: Pl. IX, Fig. 19,20: A/15/1 20.5/106 Alwinal well; depth 1353-1358 feet. Pl. IX, Figs. 26,27: S/23/1 7/104.5 Southwest Potash well; depth 1139-1144 feet.

Pl. IX, Fig. 21: S/14/1 21/93 Southwest Potash well; depth
1203-1208 feet.

Infraturma CINGULATI Potonié and Klaus emend. Dettmann 1963

Genus CONTIGNISPORITES Dettmann 1963

TYPE SPECIES: Contignisporites glebulentus Dettmann 1963.

Contignisporites sp. cf. C. cooksonii (Balme) Dettmann 1963

Plate IX, Figure 25.

For synonymy see Dettmann (1963, p. 75).

DESCRIPTION: Trilete spore; laesurae indistinct, extending to spore margin, distal face ornamented by a series of about 8 parallel rounded muri 3-6 microns wide and about 1 micron apart, muri disappear at the proximo-distal margin forming a thickened cingulum; proximal surface smooth with a few small granules.

REMARKS: Dettmann states a size range of 39 (50) 59 microns. This specimen is significantly larger.

SIZE RANGE: Equatorial diameter 47 x 77 microns. Number of specimens measured, 1.

PREVIOUS RECORDS; Contignisporites cooksonii has been described from Oxfordian to Aptian strata of Western Australia (Balme 1957); (Bolkhovitina 1961) described it from Barremian to Aptian sediments of the U.S.S.R.; reported from Aptian strata of southeast Australia (Dettmann 1963).

LOCALITY OF FIGURED SPECIMEN: Pl. IX, Fig. 25: A/12/1

11/102.5 Alwinsal well; depth 1368-1373 feet.

Contignisporites perplexus (Singh)Norris 1967

Plate IX, Figure 17,18.

1964 Appendicisporites perplexus Singh, p. 55, pl. 5, figs. 6-9.

1967 Contignisporites perplexus (Singh) Norris, p. 98, pl. 14, figs. 1-4.

DESCRIPTION: Trilete spore; laesurae simple slits or slightly gaping, bordered by a margo which becomes narrower and thinner toward the extremities, laesurae about $3/4$ spore radius; equatorial outline triangular with straight sides and rounded apices; cingulum 5-6 microns wide with thickenings at the apices adjacent to the laesurae; distal surface ornamented by a thickened triangular shield made up of a number of parallel ribs.

REMARKS: The specific name is derived from "perplexus" (intricate or involved) referring to the intricate distal ornamentation, which is described in Singh (1964, p. 55).

SIZE RANGE: Equatorial diameter 37 (43) 45 microns. Number of specimens measured, 4.

PREVIOUS RECORDS: Upper part of the Lower Cretaceous Mannville Group of Alberta (Sing 1964); Lower Cretaceous lower part of the Colorado Group of Alberta (Norris 1967).

LOCALITY OF FIGURED SPECIMENS: Pl. IX, Fig. 18: S/44/3
 14.5/101 Southwest Potash well; depth 1035-1040 feet. Pl. IX,
 Fig. 17: A/9/1 14/108.5 Alwinal well; depth 1383-1388 feet.

Genus CIRRATRIRADITES Wilson and Coe 1940

TYPE SPECIES: Cirratriradites saturni (Ibrahim) Schopf,
 Wilson and Bentall 1944 (= Sporonites saturni Ibrahim 1932).

?Cirratriradites teter Norris 1967

Plate IX, Figure 34.

1967 Cirratriradites teter Norris, p. 98, pl. 14, fig. 8.

DESCRIPTION: Trilete spore; laesurae long, extending to equator, straight, thin granulate lips, equatorial outline rounded triangular; proximal and distal surfaces granular; a thin zona-like thickening around the equator.

REMARKS: The species described here appears to be the same as that figured by Norris (1967, pl. 14, fig. 8). Neither of these forms show a well developed zona characteristic of the genus Cirratriradites although there is a faint indication of such a thickening surrounding the equator.

SIZE RANGE: Equatorial diameter 30 (38) 45 microns. Number of specimens measured, 4.

PREVIOUS RECORDS: Norris (1967) records this form from the Viking and upper shale units of the Lower Cretaceous lower part of the Colorado Group of Alberta.

LOCALITY OF FIGURED SPECIMEN: Pl. IX, Fig. 34: S/36/1
20.5/96 Southwest Potash well; depth 1085-1090 feet.

Turma MONOLETES Ibrahim 1933

Suprasubturma ACAVATOMONOLETES Dettmann 1963

Subturma AZONOMONOLETES Lubert 1935

Infraturma LAEVIGATOMONOLETI Dybova and Jachowicz 1957

Genus LAEVIGATOSPORITES Ibrahim 1933

TYPE SPECIES: Laevigatosporites vulgaris (Ibrahim) Ibrahim 1933 (=Sporonites vulgaris Ibrahim 1932).

Laevigatosporites ovatus Wilson and Webster 1946

Plate IX, Figures 23,24.

1946 Laevigatosporites ovatus Wilson and Webster, p. 271, fig. 5.

DESCRIPTION: Monolete spore; suture straight; outline reniform; exine smooth to infrapunctate.

SIZE RANGE: Length 30 (34) 39 microns; breadth 20 (24) 28 microns; length to breadth ratio (average) 1.4.

PREVIOUS RECORDS: Widley distributed in the Jurassic and Cretaceous; common in the Mannville Group and lower part of the

Colorado Group of Alberta (Norris 1967).

LOCALITY OF FIGURED SPECIMEN: Pl. IX, Figs. 23,24: S/36/2

12.5/106 Southwest Potash well; depth 1085-1090 feet.

Turma HILATES Dettmann 1963

Genus AEQUITRIRADITES Delcourt and Sprumont emend.
Cookson and Dettmann 1961

TYPE SPECIES: Aequitriradites dubius Delcourt and Sprumont
emend. Delcourt et al. 1963.

Aequitriradites spinulosus (Cookson and Dettmann)
Cookson and Dettmann 1961

Plate IX, Figure 36.

For synonymy see Singh (1964, p. 88).

DESCRIPTION: Hilate spore; laesurae indistinct to absent;
equatorial outline subcircular; central body circular in equatorial
section surrounded by a hyaline zona; proximal surface scabrate;
distal surface indistinct.

REMARKS: The ornamentation is indistinct on poorly preserved
specimens.

SIZE RANGE: Overall diameter 51 (56) 62 microns. Internal body
39 (40) 43 microns. Number of specimens measured, 5.

PREVIOUS RECORDS: Lower Cretaceous of eastern Australia
(Cookson and Dettmann 1958a); Lower and Upper Cretaceous of the

Viliuisk Basin, U.S.S.R. (Bolkhovitina 1959); Mannville Group of Alberta (Singh 1964).

LOCALITY OF FIGURED SPECIMENS: Pl. IX, Fig. 36: S/36/1
7.5/92 Southwest Potash well; depth 1085-1090 feet.

Anteturma POLLENITES Potonié 1931

Turma SACCITES Erdtman 1947

Subturma MONOSACCITES Chitaley emend. Potonié and Kremp 1954

Infraturma SACCIZONATI Bhardwaj 1957

Genus CEREBROPOLLENITES Nilsson 1958

TYPE SPECIES: Cerebropollenites mesozoicus (Couper) Nilsson
1958 (= Tsugaepollenites mesozoicus Couper 1958).

Cerebropollenites mesozoicus (Couper) Nilsson 1958

Plate IX, Figure 22.

For synonymy see Norris (1967, p. 100).

DESCRIPTION: Outline circular to subcircular; central body surrounded equatorially by a narrow bladder; exine very finely granulate to subgranulate; bladder characterized by radial folding giving it a frilled appearance.

SIZE RANGE: Equatorial diameter 37 (56) 77 microns. Number of specimens measured, 3.

PREVIOUS RECORDS: Lower Jurassic to Lower Cretaceous of Europe (Couper 1958); Albian of Maryland (Brenner 1963); Lower Cretaceous Mannville Group of Alberta (Singh 1964) and from the Lower Cretaceous lower part of the Colorado Group of Alberta (Norris 1967).

LOCALITY OF FIGURED SPECIMEN: Pl. IX, Fig. 22: S/16/2
20.5/112 Southwest Potash well; depth 1196-1198 feet.

Subturma DISACCITES Cookson 1947

Genus RUGUBIVESICULITES Pierce 1961

TYPE SPECIES: Rugubivesiculites reductus Pierce 1961.

Rugubivesiculites reductus Pierce 1961

Plate IX, Figure 54.

1961 Rugubivesiculites reductus Pierce, p. 41, pl. 2, figs. 64,65.

DESCRIPTION: Bissacate pollen, internal reticulum well developed; exine about 2 microns thick; saccate marginal frill well developed; rugulate ridges coarsely developed on central body.

SIZE RANGE: Maximum diameter 45 (48) 50 microns, including wings 74 (76) 80 microns. Number of specimens measured, .

PREVIOUS RECORDS: ?Cenomanian of Minnesota (Pierce 1961); upper Albian of the Atlantic Coastal Plain of Maryland and Delaware (1963, 1967); rare in the Viking and upper shale unit of the Lower

Cretaceous lower part of the Colorado Group of Alberta (1967).

LOCALITY OF FIGURED SPECIMEN: Pl. IX, Fig. 54: S/30/1

6.5/103 Southwest Potash well; depth 1117-1123 feet. •

Turma ALETES Ibrahim 1933

Subturma AZONALETES Luber emend. Potonié and Kremp 1954

Infraturma PSILONAPITI Erdtman emend. Potonié 1958

Genus INAPERTUROPOLLENITES Pflug ex Thomson and Pflug emend.
Potonié 1958

TYPE SPECIES: Inaperturopollenites dubius (Potonié and Venitz)

Thomson and Pflug 1953 (= Pollenites magnus dubius Potonié and
Venitz 1934).

Inaperturopollenites dubius (Potonié and Venitz)
Thomson and Pflug 1953

Plate IX, Figure 16.

For synonymy see Norris (1967, p. 104).

DESCRIPTION: Inaperturate pollen; equatorial outline sub-sphaerical; exine thin; infrapunctate to granulate.

SIZE RANGE: Equatorial diameter 20 (30) 37 microns. Number of specimens measured, 20.

PREVIOUS RECORDS: Common throughout the Jurassic, Cretaceous and Tertiary (Norris 1967).

LOCALITY OF FIGURED SPECIMENS: Pl. IX, Fig. 16: A/17/2

11/104 Alwinsal well; depth 1338-1343 feet.

Turma PLICATES Naumova emend. Potonié 1966

Subturma PRAECOLPITES Erdtman emend. Couper 1958

Genus EUCOMMIIDITES Erdtman emend. Hughes 1961

TYPE SPECIES: Eucommiidites troedssonii Erdtman emend.

Hughes 1961.

Eucommiidites troedssonii Erdtman emend. Hughes 1961

Plate IX, Figure 28.

For synonymy see Singh (1964, p. 128).

DESCRIPTION: Pollen with oval equatorial outline; median furrow extending almost whole length of grain on one side; opposite side bearing a ring furrow near the margin; exine thinner in area of ring furrow.

SIZE RANGE: Length (average) 30 microns, breadth (average) 28 microns. Number of specimens measured, 5.

PREVIOUS RECORDS: Jurassic and Lower Cretaceous (Singh 1964); Upper Jurassic and Lower Cretaceous of western Canada (Pocock 1962); Lower Lias of Sweden (Erdtman 1948); Middle and Upper Jurassic and Wealden of England (Couper 1958).

LOCALITY OF FIGURED SPECIMEN: Pl. IX, Fig. 28: S/37/3

6/101.5 Southwest Potash well; depth 1080-1085 feet.

Subturma POLYPLICATES Erdtman 1947

Genus EQUISETOSPORITES Daugherty emend. Singh 1964

TYPE SPECIES: Equisetosporites chinleana Daugherty 1941.

Equisetosporites staplinii Pocock 1965

Plate IX, Figure 29.

1965 Equisetosporites staplinii Pocock, p. 149, pl. 1, figs. 24-25.

DESCRIPTION: Acolpate pollen; ellipsoid; smooth nexine overlain by a thick sexine; sexinous ridges unbranched, straight, 3-4 microns wide in the middle, narrowing at the longitudinal ends, low gently rounded, 8 or 9 in number; furrows narrow, about 1 micron wide unbranched, ridges run obliquely across grain due to twisting.

REMARKS: Equisetosporites concinnus Singh 1964 differs in size having more and wider ridges, coalescing ridges, and is larger.

SIZE RANGE: Length 30 to 37 microns; width 14 microns. Number of specimens measured, 2.

PREVIOUS RECORDS: Middle Albian uppermost Mannville Group (Pocock 1965) of Alberta.

LOCALITY OF FIGURED SPECIMEN: Pl. IX, Fig. 29: S/23/1

15/110 Southwest Potash well; depth 1155-1160 feet.

Equisetosporites sp. A

Plate IX, Figures 30,31.

DESCRIPTION: Acolpate pollen; ellipsoidal, narrower at one end; nexine smooth; sexinousridges mainly unbranched but some branched, about 3 microns wide in the middle, low gently rounded, running obliquely across grain, about 16 in number; criss-cross pattern produced by ridges due to twisting of the grain.

SIZE RANGE: Length 67 microns; width 26 microns. Number of specimens measured, 1.

LOCALITY OF FIGURED SPECIMEN: Pl. IX, Figs. 30,31: A/8/2a
17.5/104.5 Alwinal well; depth 1388-1393 feet.

Subturma MONOCOLPATES Iversen and Troels-Smith 1950

Genus CYCADOPITES Wodehouse ex Wilson and Webster 1946

TYPE SPECIES: Cycadopites follicularius Wilson and Webster
1946.

Cycadopites fragilis Singh 1964

Plate IX, Figures 32,33.

For synonymy see Norris (1967, p. 105).

DESCRIPTION: Monosulcate pollen, fusiform; sulcus extending full length of grain, usually closed in the middle; exine faintly granular.

SIZE RANGE: Length 24 (32) 36 microns; breadth 15 (16) 19 microns. Number of specimens measured, 5.

PREVIOUS RECORDS: Jurassic and Cretaceous of western Canada (Pocock 1962, Singh 1964); Lower Cretaceous, lower part of the Colorado Group of Alberta (Norris 1967).

LOCALITY OF FIGURED SPECIMENS: Pl. IX, Fig. 32: S/20/3 3/103.5 Southwest Potash well; depth 1170-1175 feet. Pl. IX, Fig. 33: A/13/3 17/104 Alwinsal well; depth 1363-1368 feet.

Genus CLAVATIPOLLENITES Couper 1958

TYPE SPECIES: Clavatipollenites hughesii Couper 1958.

Clavatipollenites hughesii Couper 1958

Plate IX, Figures 37,38.

For synonymy see Norris (1967, p. 106).

DESCRIPTION: Monosulcate pollen; sulcus broad and running almost the whole length of the grain; grains broadly elliptical to almost circular in equatorial contour; nexine smooth; sexine with closely spaced clavate projections usually fusing at the tips.

SIZE RANGE: Length 25 (27) 29 microns; width 17 (18) 20 microns. Number of specimens measured, 8.

PREVIOUS RECORDS: Barremian to Aptian of England (Couper 1958, Hughes 1958); Barremian to Albian of Maryland (Brenner 1963); Lower Cretaceous of the Lower Colorado Group of Alberta (Norris 1967).

LOCALITY OF FIGURED SPECIMEN: Pl. IX, Figs. 37,38: A/17/11/112.5 Alwinal well; depth 1338-1343 feet.

Clavatipollenites minutus Brenner 1963

Plate IX, Figure 35.

1963 Clavatipollenites minutus Brenner, p. 95, pl. 41, figs. 8,9.

DESCRIPTION: Monocolpate pollen; furrow extending whole length of grain; equatorial outline broadly elliptical to circular; exine two layered; nexine structureless; sexine retipilate.

SIZE RANGE: Length 15 (17) 19 microns; width 9 (13) 14 microns. Number of specimens measured, 12.

PREVIOUS RECORDS: Barremian to Albian of Maryland (Brenner 1963); Lower Cretaceous Joli Fou Formation of Alberta (Norris 1967).

LOCALITY OF FIGURED SPECIMEN: Pl. IX, Fig. 35: S/30/212.5/110.5 Southwest Potash well; depth 1117-1123 feet.

Genus RETITETRADITES Pierce 1961

TYPE SPECIES: Retitetradites monocolpatus Pierce 1961.

Retitetradites monocolpatus Pierce 1961

Plate IX, Figure 52.

1961 Retitetradites monocolpatus Pierce, p. 34, pl. 2, fig. 34.

DESCRIPTION: Tetrad, four grains arranged in a tetrahedron; individual grains monocolpate; spherical, ca. 11 microns in diameter; exine reticulate.

SIZE RANGE: Equatorial diameter 9 (11) 14 microns; overall diameter of tetrad 19 (22) 28 microns. Number of specimens measured, 6.

PREVIOUS RECORDS: Cenomanian of Minnesota (Pierce 1961).

LOCALITY OF FIGURED SPECIMEN: Pl. IX, Fig. 52: S/40/3
20/105 Southwest Potash well; depth 1065-1070 feet.

Subturma TRIPTYCHES Naumova emend. Potonié 1966

Genus PSILATRICOLPITES van der Hammen 1956

TYPE SPECIES: Psilatricolporites inornatus van der Hammen
1956, pl. 9, fig. 28.

Genus PSILATRICOLPITES van der Hammen 1956

TYPE SPECIES: Psilatricolpites incomptus van der Hammen 1956.

Psilatricolpites psilatus Pierce 1961

Plate IX, Figures 39-42.

1961 Psilatricolpites psilatus Pierce, p. 49, pl. III, figs. 98,99.

DESCRIPTION: Tricolpate pollen grain; colpi elongate, furrow margins ragged; thick, psilate, exine.

SIZE RANGE: Maximum diameter ca. 14 microns. Number of specimens measured, 2.

PREVIOUS RECORDS: ?Cenomanian of Minnesota (Pierce 1961).

LOCALITY OF FIGURED SPECIMENS: Pl. IX, Figs. 39,40: S/23/2 10/100 Southwest Potash well; depth 1155-1160 feet. Pl. IX, figs. 41,42: S/36/1 6/108.5 Southwest Potash well; depth 1085-1090 feet.

Genus TRICOLPITES Cookson ex Couper emend. Potonié 1966

TYPE SPECIES: Tricolpites reticulatus Cookson 1947.

REMARKS: Srivastava (1968) has explained why Retitricolpites is not available for fossil pollen and why it is invalid. He and Potonié (1966) reject the genus and Srivastava considers it a junior synonym of Tricolpites.

Tricolpites georgensis (Brenner) n. comb.

Plate IX, Figure 43.

1963 Retitricolpites georgensis Brenner, p. 91, pl. 38, figs. 6,7.

DESCRIPTION: Tricolpate pollen grains; shape subprolate to prolate; colpi extending almost to poles; exine composed of closely spaced pila forming a reticulum; pila ca. 1 micron high, lumina ca. 1.5-2 microns across.

SIZE RANGE: Equatorial diameter 17 (21) 26 microns. Number of specimens measured, 6.

PREVIOUS RECORDS: Albion of Maryland (Brenner 1963) and Joli Fou, Viking and upper shale units of the lower part of the Colorado Group (Norris 1967).

LOCALITY OF FIGURED SPECIMEN: Pl. IX, Fig. 43: S/31/3
12/109 Southwest Potash well; depth 1110-1117 feet.

Tricolpites paraneus (Norris) n. comb.

Plate IX, Figure 45.

1967 Retitricolpites paraneus Norris, p. 109, pl. 18, figs. 15-20.

DESCRIPTION: Tricolpate pollen; subprolate to perprolate; colpi narrow, parallel sided; striate and reticulate pattern; striae closely spaced, in parallel sets, curvilinear or rectilinear, different sets often converging; ornament over entire surface including colpi.

SIZE RANGE: Equatorial diameter 11 (13) 14 microns. Polar diameter 17 (20) 22 microns. Number of specimens measured, 3.

PREVIOUS RECORDS: Joli Fou, Viking and upper shale units of the Lower Cretaceous lower part of the Colorado Group of Alberta (Norris 1967).

LOCALITY OF FIGURED SPECIMENS: Pl. IX, Fig. 45: S/37/2
7.5/95 Southwest Potash well; depth 1080-1085 feet.

Tricolpites prosimilis (Norris) n. comb.

Plate IX, Figures 46-48.

1967 Tricolpites prosimilis Norris, p. 108, pl. 18, figs. 1-4.

DESCRIPTION: Tricolpate pollen; equatorial outline oval; colpi almost reaching the poles; reticulate exine; muri 0.5 microns.

REMARKS: Distinguished from Tricolpites vulgaris (Pierce) Srivastava 1968 by its smaller size, more prolate shape and equatorial ornament which is reduced on the apocolpi.

SIZE RANGE: Equatorial diameter 11 (13) 14 microns; polar diameter 15 (17) 19 microns. Number of specimens measured, 7.

PREVIOUS RECORDS: Joli Fou, Viking and upper shale units of the lower part of the Colorado Group (Norris 1967).

LOCALITY OF FIGURED SPECIMENS: Pl. IX, Fig. 48: S/44/1
10/102 Southwest Potash well; depth 1035-1040 feet. Pl. IX, Fig. 46:
S/44/3 9/103 Southwest Potash well; depth 1035-1040 feet. Pl. IX,
Fig. 47: S/44/3 17/99 Southwest Potash well; depth 1035-1040 feet.

Tricolpites sagax Norris 1967

Plate IX, Figure 49.

1967 Tricolpites sagax Norris, p. 107, pl. 17, figs. 12-19.

DESCRIPTION: Tricolpate pollen; oblate to subprolate; equatorial outline circular to fossaperturate; colpi long, simple; sexinal elements indistinct forming a subgranular to reticulate pattern.

SIZE RANGE: Equatorial diameter 13 (17) 22 microns; polar diameter 14 to 22 microns. Number of specimens measured, 6.

PREVIOUS RECORDS: Joli Fou, Viking and upper shale units of the Lower Cretaceous lower part of the Colorado Group of Alberta (Norris 1967).

LOCALITY OF FIGURED SPECIMEN: Pl. IX, Fig. 49: S/45/2
15.5/97.5 Southwest Potash well; depth 1035-1040 feet.

Tricolpites vulgaris (Pierce) Srivastava 1968

Plate IX, Figure 44.

For synonymy see Srivastava (1968, p. 151).

DESCRIPTION: Tricolpate pollen; spheroidal to subprolate; equatorial outline circular; colpi long, unornamented; exine non-tegillate, uniformly reticulate; lumina of reticulum 0.25-0.75 microns in diameter; exine 0.5 to 1 microns thick.

SIZE RANGE: Equatorial diameter 19 (22) 28 microns; polar diameter 15 to 29 microns. Number of specimens measured, 20.

PREVIOUS RECORDS: ?Cenomanian of Minnesota (Pierce 1961); Albian of Maryland (Brenner 1963); lower part of the Colorado Group (Albian? to Cenomanian) of Alberta (Norris 1967).

LOCALITY OF FIGURED SPECIMEN: Pl. IX, Fig. 44: S/22/3 12/110 Southwest Potash well; depth 1160-1165 feet.

Turma POROSES Naumova emend. Potonié 1966

Subturma MONOPORINES Naumova emend. Potonié 1966

Genus CLASSOPOLLIS Pflug emend. Couper 1958

TYPE SPECIES: Classopollis torosus (Reissinger) Balme 1957 (= Pollenites torosus Reissinger 1950).

Classopollis torosus (Reissinger) Couper 1958

Plate IX, Figure 50.

For synonymy see Norris (1967, p. 110).

DESCRIPTION: Monoporate pollen; grains originally spherical but frequently distorted so equatorial contour is sub-circular or suboval; exine subgranulate to pitted; annular equatorial thickening composed of thin bands about 1 micron wide forming a thickened zone about 3-5 microns wide.

SIZE RANGE: Equatorial diameter 24 (29) 33 microns. Number of specimens measured, 14.

PREVIOUS RECORDS: World wide distribution from Upper Triassic to Lower Cretaceous; according to Couper (1964) it occurs last in the Cenomanian; lower part of the Lower Cretaceous Colorado Group of Alberta (Norris 1967).

LOCALITY OF FIGURED SPECIMEN: Pl. IX, Fig. 50: A/17/1
5.5/101.5 Alwinsal well; depth 1338-1343 feet.

Genus CIRCULINA Maljavkina ex Klaus 1960

TYPE SPECIES: Circulina meyeriana Klaus 1960.

Circulina parva Brenner 1963

Plate IX, Figure 51.

1963 Circulina parva Brenner, p. 84, pl. 34, figs. 2,3.

DESCRIPTION: Monoporate pollen; laesurae form a triangular opening on the proximal side; distal pole with a thin circular area 3-5 microns wide; a furrow encircles the distal side separating an outer ring-like zone 2-4 microns wide from a circular polar area; exine smooth.

SIZE RANGE: Equatorial diameter 13 (19) 23 microns. Number of specimens measured, 20.

PREVIOUS RECORDS: Recovered by Brenner (1963) from the Potomac Group of Maryland (upper Barremian to upper Albian); upper Mannville and lower part of the Colorado Group of Alberta (Norris 1967).

LOCALITY OF FIGURED SPECIMEN: Pl. IX, Fig. 51: S/5/1
18.5/105 Southwest Potash well; depth 1253-1258 feet.

Sporae Dispersae Incertae Sedis

Genus SCHIZOSPORIS Cookson and Dettmann 1959

TYPE SPECIES: Schizosporis reticulatus Cookson and Dettmann
1959.

Schizosporis cf. S. reticulatus Cookson and Dettmann 1959

Plate IX, Figure 53.

DESCRIPTION: Spore biconvex, polar outline circular; exine coarsely reticulate, with polyhedral lumina 8-12 microns in diameter, muri about 1 micron wide.

REMARKS: The specimens described by Cookson and Dettmann (1959) are slightly larger and the reticulum is somewhat finer. They also give a size range of 90-135 microns for Australian specimens.

SIZE RANGE: Equatorial diameter 80 (88) 93 microns. Number of specimens measured, 3.

PREVIOUS RECORDS: Reported in sediments from Lower Cretaceous to ?Cenomanian in western Canada (Pocock 1962, Singh 1964) and Australia (Cookson and Dettmann 1959); recovered in Aptian to Albian sediments in Maryland (Brenner 1963) and from the Cenomanian of Oklahoma (Hedlund 1966); Norris (1963) reported it from Berriasian strata of England and Norris (1967) found it restricted to the Viking Formation in the Lower Cretaceous lower part of the Colorado Group of Alberta.

LOCALITY OF FIGURED SPECIMEN: Pl. IX, Fig. 53: S/17/2
11.5/100.5 Southwest Potash well; depth 1191-1196 feet.

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APPENDIX I

SAMPLE LOCATION, PREPARATION AND STUDY TECHNIQUES

Samples used for microfloral studies were selected from cored intervals in two drill-holes in central and east-central Saskatchewan. The sample interval extended from the top of the Swan River Group to the base of the Fish Scale Zone, thus covering the lower part of the Ashville Formation. Samples were taken throughout approximately 5 foot intervals through the sample interval in each well. Next, the samples were mechanically crushed and placed in polythene bags. A total of 63 samples were studied.

DRILL-HOLE LOCATION, THICKNESS OF THE SAMPLED INTERVAL AND
NUMBER OF SAMPLES FROM EACH DRILL-HOLE

Well: Alwinsal Sarcee 4-28

Location: Lsd. 4, Sec. 28, Tp. 33, R. 23, W. 2nd Mer.

K.B. 1771.3'

Thickness from the top of the Swan River Group to the base of the Fish Scale Zone = 110' (1440' to 1330').

Number of Samples: 18

Well: Southwest Potash Bredenbury 11-36

Location: Lsd. 11, Sec. 36, Tp. 22, R. 1, W. 2nd Mer.

K.B. 1760.8'

Thickness from the top of the Swan River Group to the base of the Fish Scale Zone = 245' (1275' to 1030').

Number of Samples: 45

Sample Preparation

The preparation technique employed was basically that outlined by Funkhouser and Evitt (1959), and the filtration system of Neves (1963). Modifications were also made for the particular lithology and organic content of each sample dealt with. Superfluous inorganic and organic debris did not pose problems in most samples so it was felt a heavy liquid separation technique was not warranted. After each chemical treatment the sample was washed either by filtering it through sutured glass filter funnels or by short centrifuging and retaining only the heavy residue.

From the crushed sample five pea-sized amounts of material were selected. These were washed with distilled water and placed in 250 cc polythene containers.

Chemical Maceration

As many of the samples were at least slightly calcareous each was treated with 38% (maximum) hydrochloric acid for 12 hours; then diluted twice with distilled water. To digest silicate material the samples were then digested in 48% (maximum) hydrofluoric acid for 48 hours, then diluted about 6 times with distilled water until neutral. The amount of acid used in both the case of hydrochloric and hydrofluoric was a volume sufficient to just cover the sample. More acid was added periodically if thought necessary for complete digestion. At this point a small portion of the sample was transferred from the polythene containers to 150 ml - 60 M sutured filter funnels. The remainder of the sample was stored in small glass bottles fitted with plastic caps.

While in the funnels the samples were rinsed with distilled water and then oxidized with 2% potassium hydroxide solution in order to digest superfluous organic material. Samples were treated until the solution began to turn brown (up to 10-20 minutes). Small amounts of sample were pipetted at intervals and examined under the microscope to determine if oxidation had been sufficient and also to ensure the microflora were not being dissolved or damaged. For some samples this treatment was not adequate; these samples were further oxidized with fresh Schulze's solution for periods up to 15 minutes or until the solution began to turn brown. The sample was then neutralized by adding potassium hydroxide and distilled water.

Staining

Samples were stained with 0.5% Safranin O until the microflora appeared pink. Excess stain was washed through the sutured glass filter funnels or, if necessary, by short centrifuging. The concentrated sample residue was then transferred to small glass bottles fitted with plastic caps for temporary storage.

Slide Preparation

Slides were prepared with a portion of the concentrated residue. In a small glass vial, 35 x 12 mm, were placed 3 drops of Elvanol, 3 drops of distilled water and 3 to 5 drops of concentrated sample residue depending on the concentration of microflora in it. This mixture was thoroughly mixed and then spread on cover slips using a pipette. When dry each cover slip was placed on a small hot plate along with a clean microscope slide and warmed. The warm cover

slip was then covered with a layer of Canada Balsam and carefully lowered onto the warmed slide. A small spatula was used to force out air bubbles trapped under the cover slip. The slide was removed from the hot plate, labelled and let dry. Excess Canada Balsam was removed with a sharp knife and xylene. Three slides were prepared of each sample.

Examination of Microscope Slides

Each of the three slides was scanned lengthwise at intervals of 1 mm, under low power magnification (x125). All identifiable pollen, spores and microplankton were recorded. For scanning and identification a Leitz Laborlux microscope (Serial Number 657084), located in the micropaleontology laboratory at the University of Alberta, was used: all mechanical stage readings cited herein refer to this microscope.

Photomicrographs

Photomicrographs were taken with a Leitz Orthomat (Serial Number 594208) microscope fitted with a 35 mm camera. Specimens were photographed using the (100x) objective lens and oil immersion when possible. For larger specimens the x40 objective lens was used. Adox KB 14 35 mm film was used. For thick or darkly stained specimens Polycontrast F red filters were employed as well as an ASA reading of 12 instead of the normal 25 ASA for this film. Photographs were printed on Kodak Polycontrast F paper.

All figured specimens are magnified at x500 or x1000.

Locality of Specimens and Repository

Each sample was assigned a letter and sample number.

Samples from Alwinsal Sarcee 4-28 drill-hole were assigned the letter "A" followed by a number (1 to 18); samples from Southwest Potash Bredenbury were assigned the letter "S" followed by a sample number (1 to 45). This was followed by the slide number of each sample, usually 1 to 3 and finally the microscope coordinates were stated (horizontal/vertical).

Example: A/17/1 9/120

The letter A indicates the sample is from the Alwinsal Sarcee 4-28 drill-hole. It is sample number 17 microscope slide number 1. The horizontal microscope stage coordinate is 9 and the vertical coordinate is 120.

All slides are deposited in the palynological collection of the Department of Geology, University of Alberta.

APPENDIX II

LITHOLOGIC SUMMARY

Well: Alwinsal Sarcee 4-28

Company: Alwinsal Sarcee of Canada Ltd.

Location: Lsd. 4, Sec. 28, Tp. 23, R. 33, W. 2nd Mer.

K.B. 1771.3'

Interval Sampled: 1330' to 1440' from base of the Fish Scale Zone
to the top of the Swan River Group.

Sample Number	Core Interval (in feet)	Description
A/18	1333-1338	Shale-grey, silty, slightly calcareous, trace of glauconite and pyrite.
A/17	1338-1343	Shale-grey to dark grey with traces of pyrite.
	1343-1348	No sample.
A/16	1348-1353	Shale-grey, silty to very fine quartz rich sandstone microlenses, partly fissile.
A/15	1353-1358	Shale-grey, slightly silty to very fine slightly calcareous glauconitic sandstone, fissile.
A/14	1358-1363	Shale-grey, with a few light grey silty slightly calcareous laminations, trace of pyrite.
A/13	1363-1368	Shale-grey with light grey silty to very fine quartz rich sandstone lenses, trace of pyrite.
A/12	1368-1373	Shale-grey, with a few slightly calcareous silty laminations, trace of pyrite.

A/11	1373-1378	Shale-grey, silty to very fine slightly calcareous glauconitic quartz rich sandstone.
A/10	1378-1383	Shale-grey, trace of pyrite.
A/9	1383-1388	Shale-dark grey with light grey silty laminations, trace of pyrite.
A/8	1388-1393	Shale-dark grey, trace of pyrite.
A/7	1393-1398	Shale-grey with a trace of very fine grey glauconitic sandstone and siltstone, slightly calcareous with micro laminations, trace of pyrite.
A/6	1398-1403	Shale-grey, slightly silty to slightly calcareous quartz rich siltstone laminations.
A/5	1403-1408	Shale-grey to dark grey, silty to very fine slightly calcareous glauconitic sandstone micro-lenses.
A/4	1408-1413	Shale-grey, with a few light grey silty slightly glauconitic laminations, trace of pyrite.
	1413-1419	No sample.
A/3	1419-1425	Shale-grey to dark grey, silty, slightly calcareous, glauconitic micro lenses.
	1425-1431	No sample.
A/2	1431-1437	Shale-dark grey with a few laminations of silty very fine calcareous light grey sandstone.
A/1	1437-1442	Shale-dark grey, fissile, trace of pyrite.

Well: SWP Bredenbury 11-36

Company: Southwest Potash Corporation

Location: Lsd. 11, Sec. 36, Tp. 22, R. 1. W. 2nd Mer.

K.B. 1760.8'

Interval Samples: 1030' to 1275' from the base of the Fish Scale Zone to the top of the Swan River Group.

Sample Number	Core Interval (in feet)	Description
S/45	1030-1035	Shale - grey, very slightly calcareous, trace of pyrite.
S/44	1035-1040	Shale - grey to dark grey, silty to very fine sandstone laminations, slightly calcareous, trace of pyrite.
S/43	1040-1045	Shale - grey to dark grey, slightly calcareous, trace of pyrite.
	1045-1050	No sample.
S/42	1050-1055	Shale - grey and siltstone to very fine, light grey, quartz rich sandstone.
	1055-1060	No sample.
S/41	1060-1065	Shale - dark grey, silty, slightly calcareous.
S/40	1065-1070	Shale - dark grey.
S/39	1070-1075	Shale - dark grey, trace of pyrite.
S/38	1075-1080	Shale - grey to dark grey.
S/37	1080-1085	Shale - grey to dark grey brown, trace of pyrite along laminations.
S/36	1085/1090	Shale - grey, some silty laminations, slightly calcareous, trace of pyrite.

S/35	1090-1095	Shale - grey, slightly calcareous, pyrite.
S/34	1095-1100	Shale - dark grey to grey brown, slightly calcareous.
S/33	1100-1105	Shale - dark grey to dark grey brown, slightly calcareous, trace of pyrite.
S/32	1105-1110	Shale - dark grey.
S/31	1110-1117	Shale - dark grey, slightly calcareous.
S/30	1117-1123	Shale - dark grey brown-grey, silty to very fine quartz-rich sandy laminations.
S/29	1123-1129	Shale - grey, silty and very fine grey quartz rich sandstone, glauconite, trace of pyrite.
S/28	1129-1134	Shale - grey to grey brown, and siltstone to very fine quartz rich, slightly calcareous, glauconitic sandstone.
S/27	1134-1139	Shale - grey and light grey bentonite.
S/26	1139-1144	Shale - grey, slightly calcareous, trace of pyrite.
S/25	1144-1149	Shale - grey with a few laminations of quartz rich, slightly calcareous siltstone to very fine sandstone, trace of pyrite.
S/24	1149-1150	Shale - grey to grey brown, silty, trace of pyrite.
	1150-1155	No sample.
S/23	1155-1160	Shale - dark grey, slightly silty and slightly calcareous.
S/22	1160-1165	Shale - grey to dark grey brown, slightly silty and slightly calcareous, trace of pyrite.
S/21	1165-1170	Shale - dark grey.

S/20	1170-1175	Shale - grey, slightly silty, slightly calcareous.
	1175-1181	No sample.
S/19	1181-1186	Shale - grey, and sandstone - grey, very fine quartzose, calcareous, trace of pyrite.
S/18	1186-1191	Shale - grey, silty, slightly calcareous.
S/17	1191-1196	Shale - dark grey with a few irregular micro-lenses of siltstone.
S/16	1196-1198	Shale - grey, laminated, slightly calcareous.
S/15	1198-1203	Shale - grey to dark grey, trace of pyrite, with irregular micro-lenses of quartz-rich glauconitic siltstone.
S/14	1203-1208	Shale - grey, trace of pyrite with irregular laminations or micro-lenses of light grey silt to very fine sandstone.
S/13	1208-1213	Shale - grey with light grey slightly calcareous silty laminations, trace of pyrite.
S/12	1213-1220	Shale - grey with grey silty slightly calcareous laminations, trace pyrite.
S/11	1220-1225	Shale - grey.
S/10	1225-1230	Shale - grey, with irregular micro-lenses of slightly calcareous siltstone, trace of pyrite.
S/9	1230-1235	Shale - grey with silty laminations and micro-lenses.
S/8	1235-1240	Shale - grey to dark grey, with laminations of light grey glauconitic siltstone to very fine sandstone, trace of pyrite.

S/7	1240-1245	Shale - grey with light grey glauconitic silty to very fine sandstone micro-lenses.
	1245-1250	No sample.
S/6	1249-1253	Shale - grey with slightly calcareous very fine quartz rich sand laminations.
S/5	1253-1258	Shale - grey, trace of pyrite, with a few silty to very fine glauconitic sandstone laminations.
S/4	1258-1263	Shale - grey, slightly calcareous, slightly silty, trace of pyrite.
S/3	1263-1268	Shale - grey to dark grey with micro-lenses of glauconitic calcareous grey siltstone to very fine sandstone.
S/2	1268-1273	Shale - grey to dark grey, trace of pyrite with a trace of glauconitic grey siltstone.
	1273-1278	No sample.
S/1	1278-1283	Shale - grey to dark grey, trace of pyrite.

PLATE I

(All figures are illustrated at a magnification of
x500 unless otherwise stated)

- 1 Leptodinium cf. L. eumorphum(Cookson and Eisenack)
Eisenack 1961; ventral view..... (p.66)
- 2,7 Cribroperidinium cf. C. orthoceras Eisenack emend.
Sarjeant 1966; fig. 2 lateral view; fig. 7
ventral view showing archeopyle..... (p.64)
- 3 Gonyaulacysta whitei Sarjeant 1966; dorsal view..... (p.61)
- 4,11 Cribroperidinium cf. C. muderongensis (Cookson and
Eisenack) Sarjeant 1966; fig. 4 ventral view
showing archeopyle and membranes; fig. 11 ventral
view showing archeopyle and ornamentation..... (p.63)
- 5,6,8 Cribroperidinium intricatum Davey 1969; fig. 5
ventral view showing archeopyle, note
longitudinal furrow; fig. 6 lateral view;
fig. 8 lateral view showing archeopyle and
membraneous ornamentation..... (p.62)
- 9 Pareodinia sp. A; lateral view..... (p.67)
- 10 Leptodinium delicatum(Davey) Sarjeant 1969;
lateral view..... (p.67)

PLATE I.

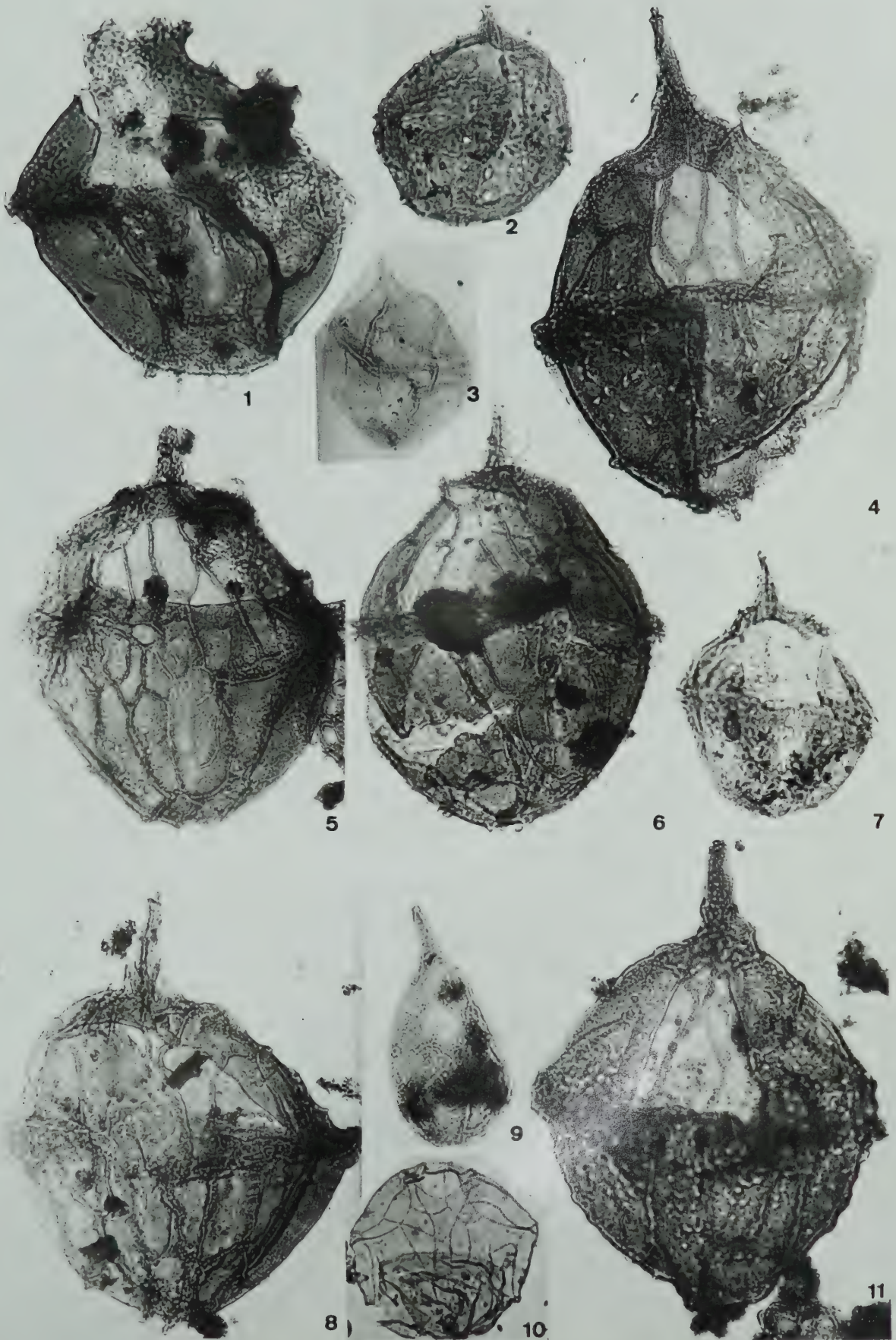


PLATE II

(All figures are illustrated at a magnification of
x500 unless otherwise stated)

- | | |
|----------|--|
| 1,7 | ? <u>Cribroperidinium</u> sp. A; fig. 1 lateral view showing archeopyle; fig. 7 lateral view..... (p.64) |
| 2 | <u>Canningia colliveri</u> Cookson and Eisenack 1960; lateral view showing angular outline of archeopyle..... (p.75) |
| 3,4 | <u>Broomea jaegeri</u> Alberti 1961; fig. 3 ventral view, note angular plate outline; fig. 4 dorsal view..... (p.76) |
| 5,8 | ? <u>Cribroperidinium</u> sp. B; fig. 5 dorsal view; fig. 8 dorsal view..... (p.65) |
| 6 | <u>Spinidinium microceratium</u> Stanley 1962; ventral view showing intercalary archeopyle..... (p.69) |
| 9,15 | <u>Apteodinium granulatum</u> Eisenack 1958b; fig. 9 ventral view showing precingular archeopyle and granular ornamentation; fig. 15 dorsal view, note spiralling cingulum..... (p.68) |
| 10,11,14 | <u>Trichodinium</u> cf. <u>T. hirsutum</u> Cookson 1965; fig. 10 ventral view; fig. 11 dorsal view; fig. 14 ventral view showing large antapical progress..... (p.71) |
| 12 | <u>Canningia</u> cf. <u>C. reticulata</u> Cookson and Eisenack 1960; lateral view showing angular outline of archeopyle..... (p.76) |
| 13 | <u>Tenua</u> sp. A; lateral view showing angular outline of archeopyle, note vertical slits around edge indicating plate areas..... (p.74) |
| 16 | <u>Fromea amphora</u> Cookson and Eisenack 1958; lateral view showing apical archeopyle..... (p.72) |
| 17 | ? <u>Fromea</u> sp. A; lateral view showing apical archeopyle and characteristic folds..... (p.73) |

PLATE II.



PLATE III

(All figures are illustrated at a magnification of
x500 unless otherwise stated)

- 1,2 Hystrichosphaeridium salpingophorum Deflandre 1935;
fig. 1 antapical view; fig. 2 lateral view showing
apical archeopyle..... (p.78)
- 3,4 Hystrichosphaeridium stellatum Maier 1959; fig. 3
lateral view showing larger fenestrate antapical
process; fig. 4 lateral view..... (p.79)
- 5 ? Cleistosphaeridium aciculare Davey 1969; lateral
view showing small apical archeopyle..... (p.79)
- 6,7 Cleistosphaeridium sp. A; fig. 6 lateral view
showing apical archeopyle; fig. 7 showing apical
archeopyle..... (p.81)
- 8,12 Cleistosphaeridium sp. B; 8 lateral view
showing apical archeopyle; fig. 12 lateral view
of complete specimen with apical portion..... (p.82)
- 9 Cleistosphaeridium polypes (Cookson and Eisenack)
Davey 1969; antapical view..... (p.80)
- 10,11 Cordosphaeridium cf. C. inodes (Klump) Davey
and Williams 1966; fig. 10 lateral view showing
large rounded triangular archeopyle, fig. 11
lateral view..... (p.83)
- 13 Cordosphaeridium cf. C. multispinosum Davey and
Williams 1966; lateral view showing rounded
apical archeopyle..... (p.84)
- 14,15 Coronifera cf. C. oceanica Cookson and Eisenack
1958; fig. 14 lateral view; fig. 15 lateral view.... (p.87)
- 16,18 Litosphaeridium sp. A; fig. 16 antapical view; fig.
18 antapical view..... (p.87)
- 17 Litosphaeridium siphoniphorum Cookson and Eisenack
emend. Davey and Williams 1966; lateral view
showing thick reticulate body wall..... (p.86)
- 19,22 Oligosphaeridium albertense (Pocock) Davey and
Williams 1966; fig. 19 antapical view, fig. 22
lateral view showing archeopyle..... (p.88)
- 20,21 Hystrichokolpoma unispinum Williams and Davey 1966;
fig. 20 apical view, note granular nature of
processes; fig. 21 lateral view..... (p.85)

PLATE III.

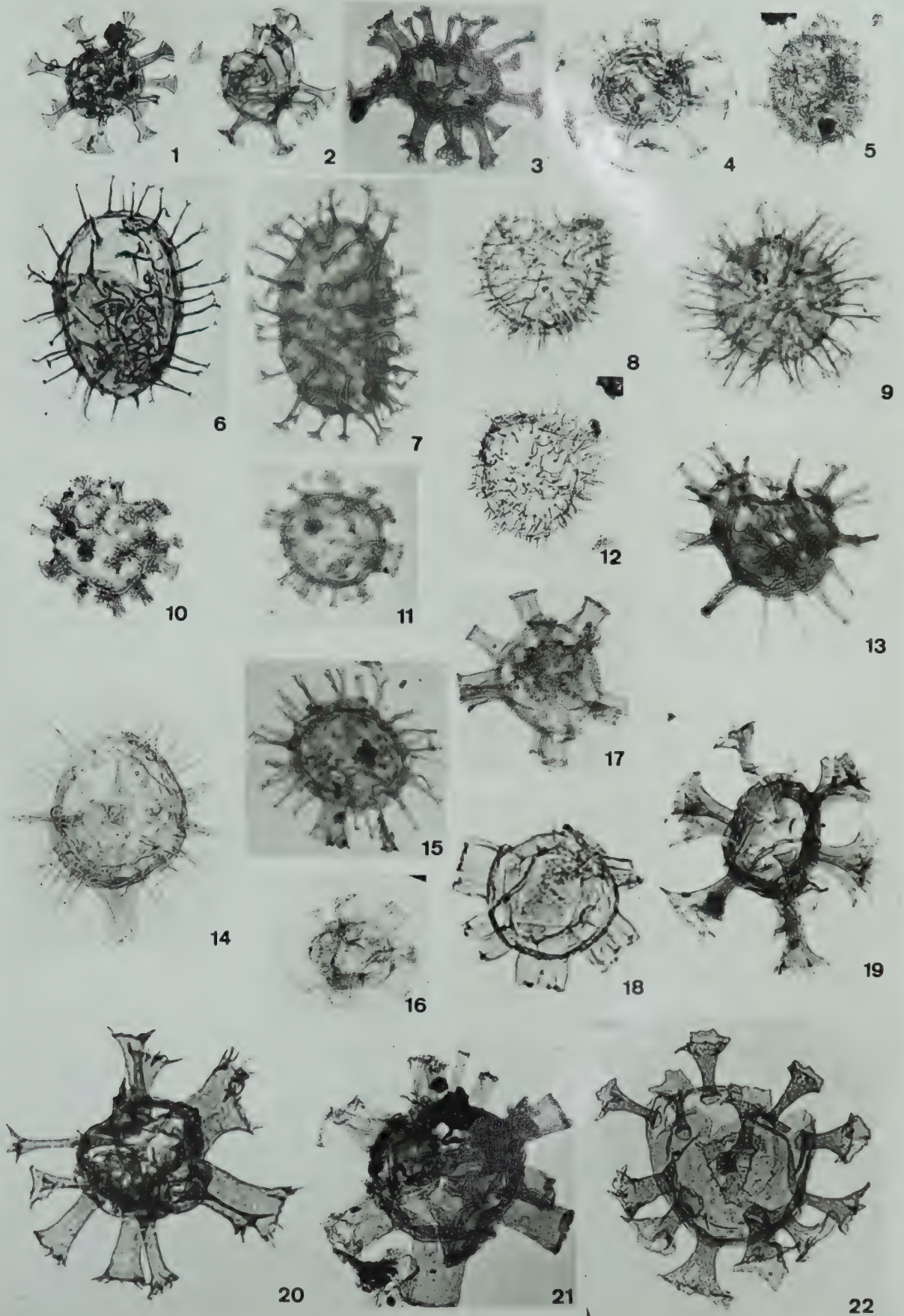


PLATE IV

(All figures are illustrated at a magnification of
x500 unless otherwise stated)

- 1,3 Oligosphaeridium anthophorum Cookson and Eisenack
1958; fig. 1 lateral view showing apical
archeopyle and fenestrate processes; fig. 2
oblique view showing archeopyle and fenestrate
processes..... (p.89)
- 2,4-6 Oligosphaeridium complex (White) Davey and
Williams 1966; fig. 2 lateral view showing
angular apical archeopyle; figs. 4,5,6 lateral
view..... (p.90)
- 7,8 Oligosphaeridium pulcherrimum Deflandre and
Cookson 1966; fig. 7 lateral view; fig. 8
lateral view..... (p.91)
- 9-11,14 Oligosphaeridium reticulatum Davey and Williams
1966; figs. 9-11 lateral views showing angular
opening of apical archeopyle and reticulate
nature of body wall; fig. 14 oblique view..... (p.92)
- 12 Prolixosphaeridium sp. A; lateral view showing
elongate body, apical archeopyle and closed
processes..... (p.94)
- 13 Polysphaeridium sp. A; lateral view showing
angular apical archeopyle granular elongate
body..... (p.94)

PLATE IV.

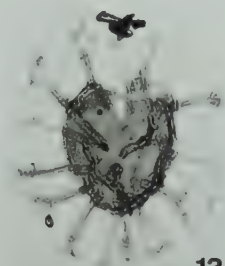
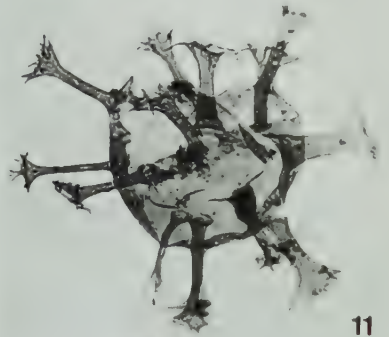
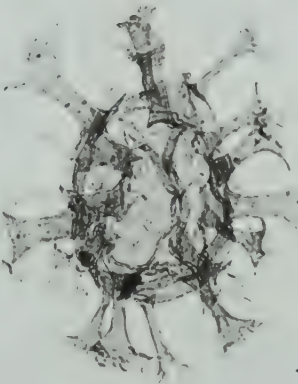
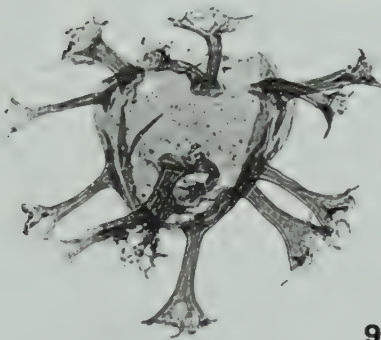
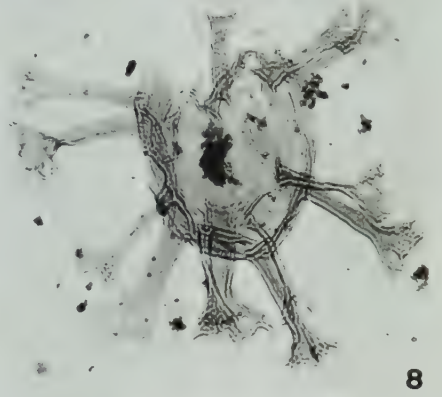
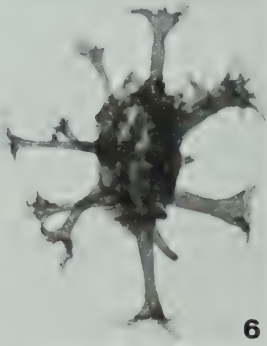
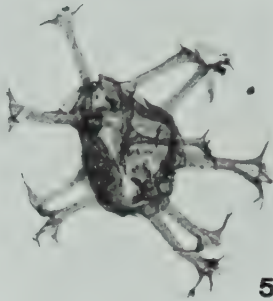
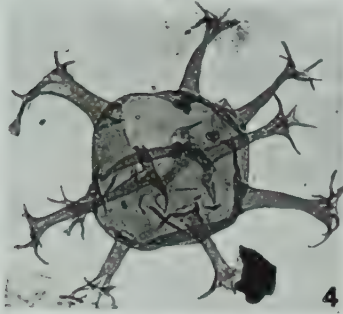
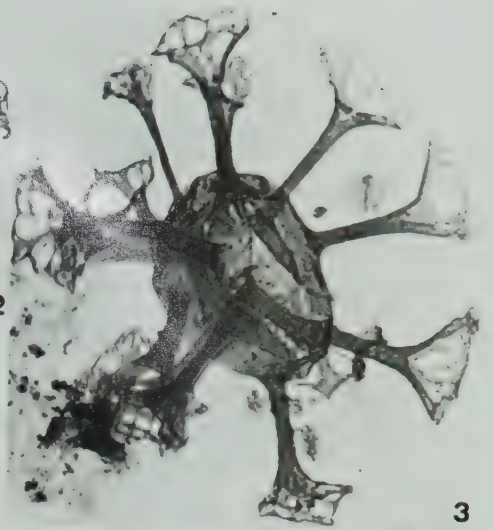
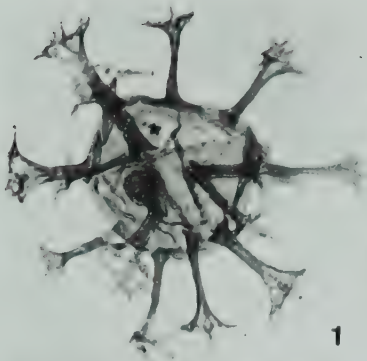


PLATE V

(All figures are illustrated at a magnification of
x500 unless otherwise stated)

- 1,2,5 Tanyosphaeridium variecalamum Davey and Williams 1966; figs. 1,2 lateral views showing elongate body with apical archeopyles; fig. 5 lateral view of complete specimen..... (p.96)
- 3 Tanyosphaeridium sp. A; fig. 3 lateral view showing elongate granular body with apical archeopyle, note the wider less numerous processes..... (p.97)
- 4,6 Cyclonephelium distinctum Deflandre and Cookson 1955; figs. 4,6 lateral views showing archeopyle and restricted nature of ornamentation..... (p.98)
- 7 Systematophora schindewolfi (Alberti) Neale and Sarjeant 1960; lateral view showing fine fenestrate processes..... (p.95)
- 8,9,11,13 Cyclonephelium eisenacki Davey 1969; fig. 8 lateral view of a complete specimen and ornamentation restricted to the sides of the body; fig. 9 lateral view of complete specimen with less restriction of processes; figs. 11 and 13 complete specimens with operculum in different stages of removal..... (p.99)
- 10 Cyclonephelium sp. A; lateral view showing zig-zag archeopyle edge and membranous processes..... (p.100)
- 12 Dinopterygium cladoides Deflandre 1935; apical view..... (p.108)
- 14 Deflandre pirnaensis Alberti 1959; lateral view..... (p.110)
- 15 Deflandre cf. D. pirnaensis Alberti 1959; lateral view with break in position of intercalary archeopyle..... (p.111)
- 16 Deflandre cf. D. cincta Cookson and Eisenack 1958; lateral view..... (p.109)
- 17 Cyclonephelium sp. B; lateral view showing laterally restricted ornamentation and apical ornamentation..... (p.100)

PLATE V

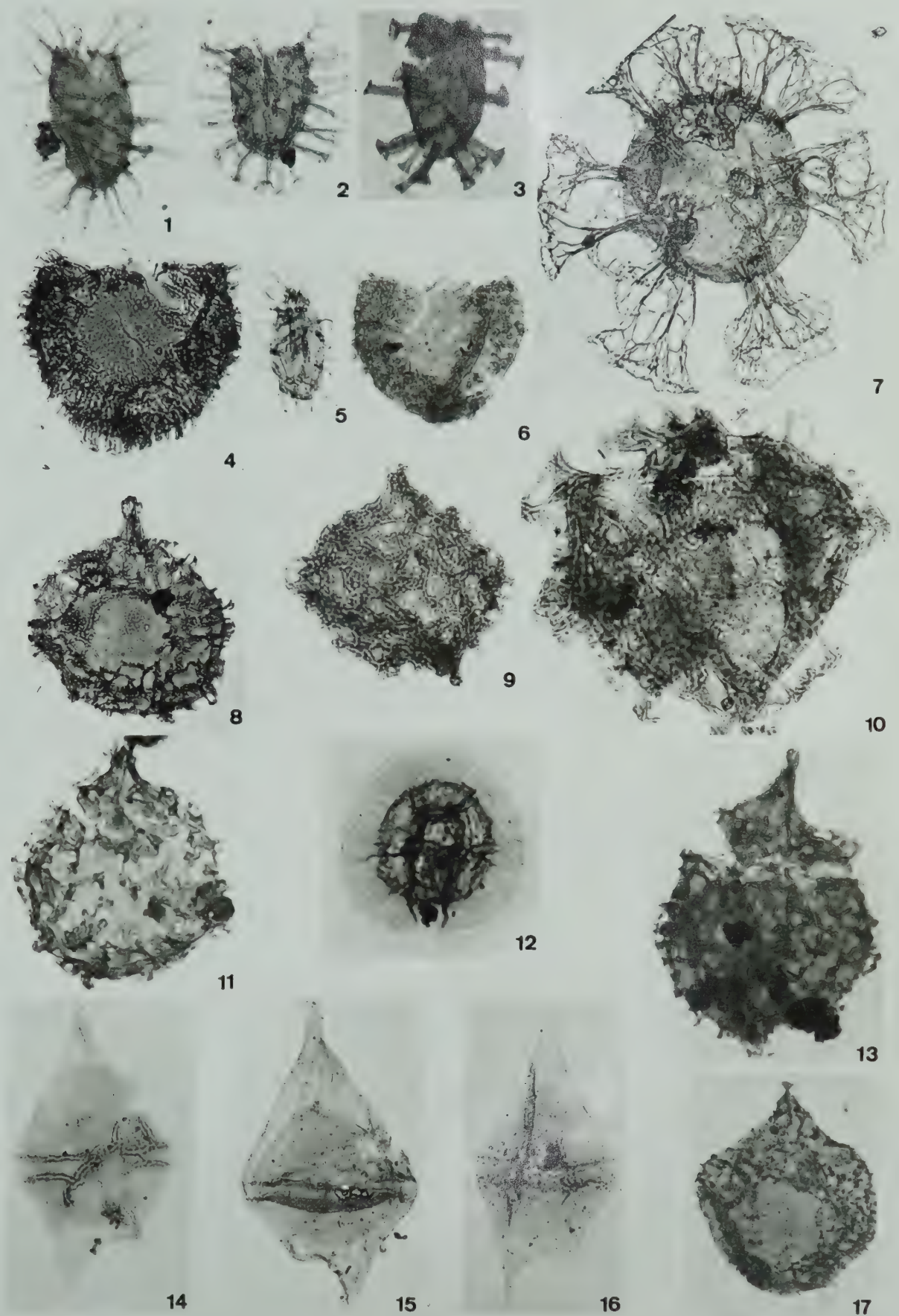


PLATE VI

(All figures are illustrated at a magnification of
x500 unless otherwise stated)

- 1-3 Hystrichosphaera cingulata var. reticulata Davey
and Williams 1966; figs. 1-3 lateral views
showing archeopyle..... (p.101)
- 4,8 Hystrichosphaera ramosa (Ehrenberg) var.
ramosa Davey and Williams 1966; fig. 4 and fig. 8
lateral views showing fine processes..... (p.102)
- 5,6 Hystrichosphaera ramosa var. gracilis Davey and
Williams 1966; figs. 5 and 6 lateral views..... (p.103)
- 7,9 Hystrichosphaera ramosa var. granomembranacea
Davey and Williams 1966; fig. 7 lateral view;
fig. 9 lateral view showing granular nature of
body wall..... (p.104)
- 10 Hystrichosphaera ramosa var. membranacea (Rossignol)
Davey and Williams 1966; fig. 10 lateral view..... (p.104)
- 11 Hystrichosphaera ramosa var. reticulata Davey
and Williams 1966; lateral view showing
precingular archeopyle..... (p.105)
- 12 Hystrichosphaera ramosa var. indet.; ventral
view showing two distinct antapical processes..... (p.106)
- 13 Scriniodinium eurypylum Manum and Cookson 1964;
lateral view showing split in position of
precingular archeopyle..... (p.115)
- 14 Hystrichodinium oligacanthum Deflandre and Cookson
1955; oblique view showing plates and ornamentation. (p.107)
- 15 Stephodinium coronatum Cookson and Hughes 1964;
apical view showing lateral flange..... (p.125)
- 16 Scriniodinium sp. A; ventral view showing
precingular archeopyle..... (p.116)
- 17 Scriniodinium sp. B; ventral view showing pre-
cingular archeopyle..... (p.117)
- 18 Scriniodinium campanula Gocht 1959; ventral view
showing inner body and small circular opening at
bottom left..... (p.113)

19,20 Ascodinium verrucosum Cookson and Hughes 1964;
fig. 19 ventral view showing complete specimen
and split in position of apical archeopyle; fig. 20
incomplete specimen showing apical archeopyle..... (p.118)

21 Scriniodinium cf. S. ceratophorum Cookson and Eisenack
1960; dorsal view..... (p.115)

PLATE VI.

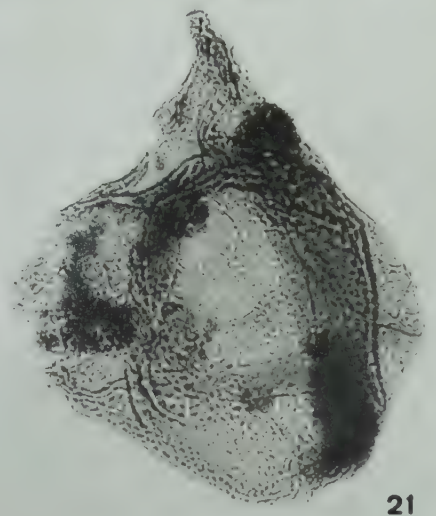
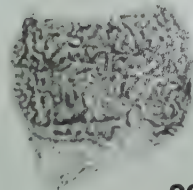
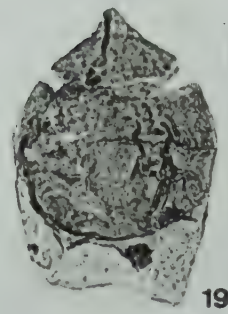
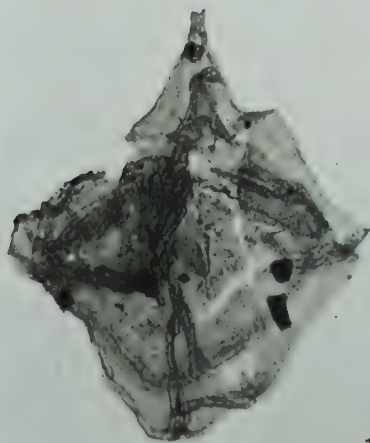
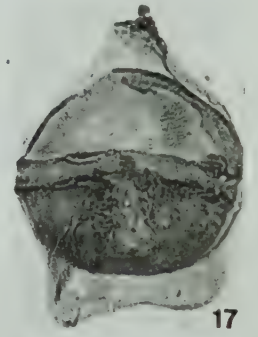
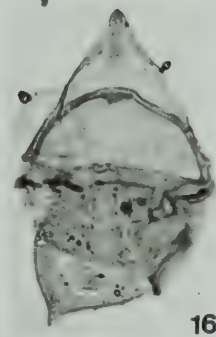
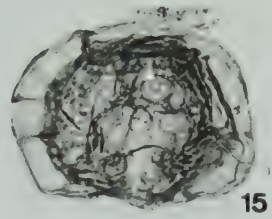
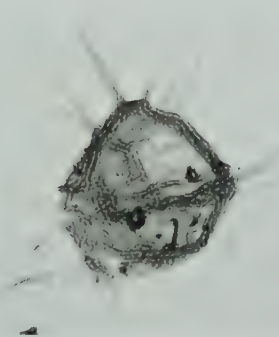
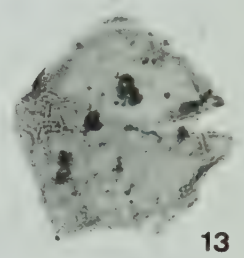
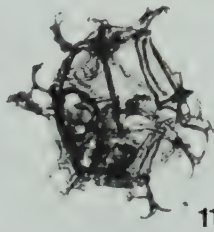
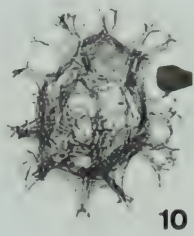
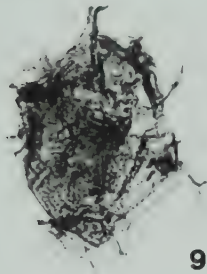
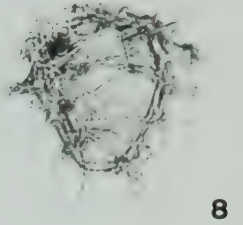
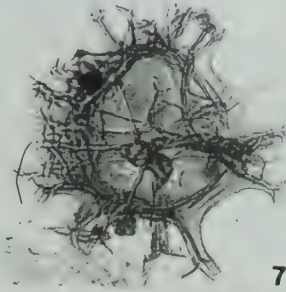
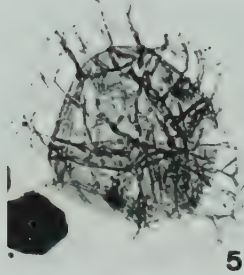
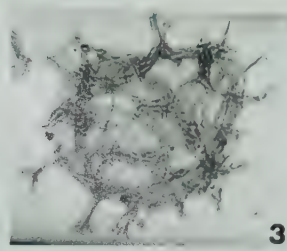
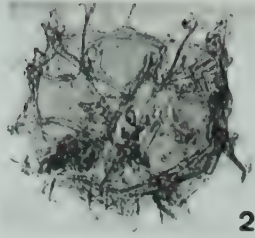
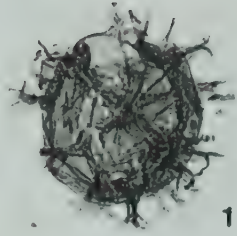


PLATE VII

(All figures are illustrated at a magnification of
x500 unless otherwise stated)

1-3	<u>Pseudoceratium</u> sp. A; fig. 1 lateral view of complete specimen; fig. 2 lateral view of specimen without apical portion showing apical archeopyle; fig. 3 lateral view of complete specimen.....	(p.120)
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5,6	<u>Odontochitina</u> <u>costata</u> Alberti 1967; figs. 5 and 6 lateral views x ca. 50.....	(p.121)
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PLATE VII.

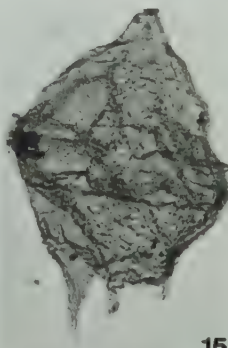
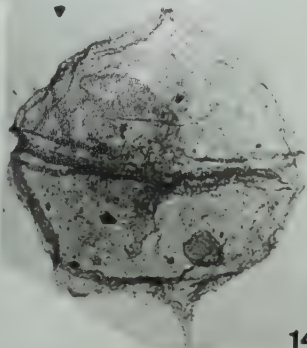
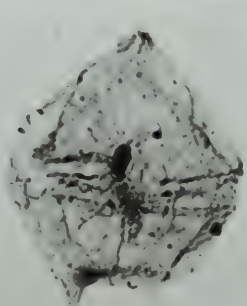
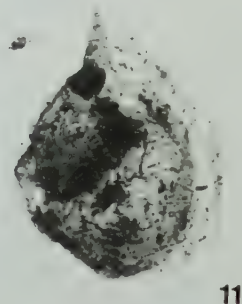
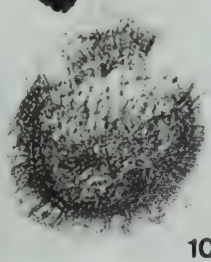
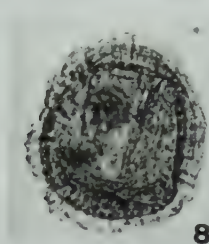
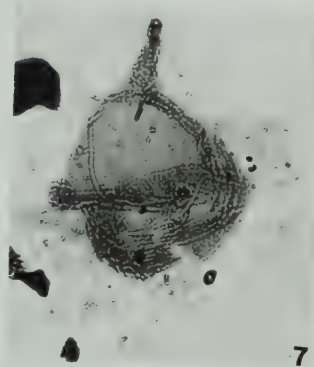
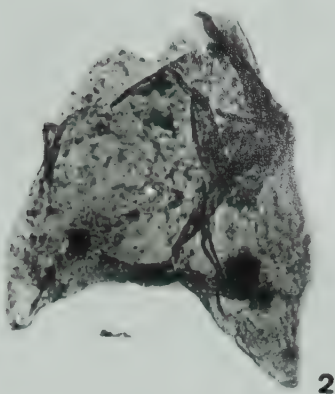
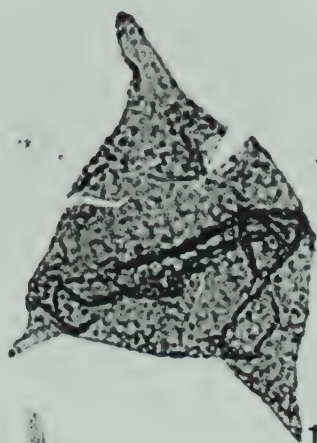


PLATE VIII

(All figures are illustrated at a magnification of
x500 unless otherwise stated)

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PLATE VIII.

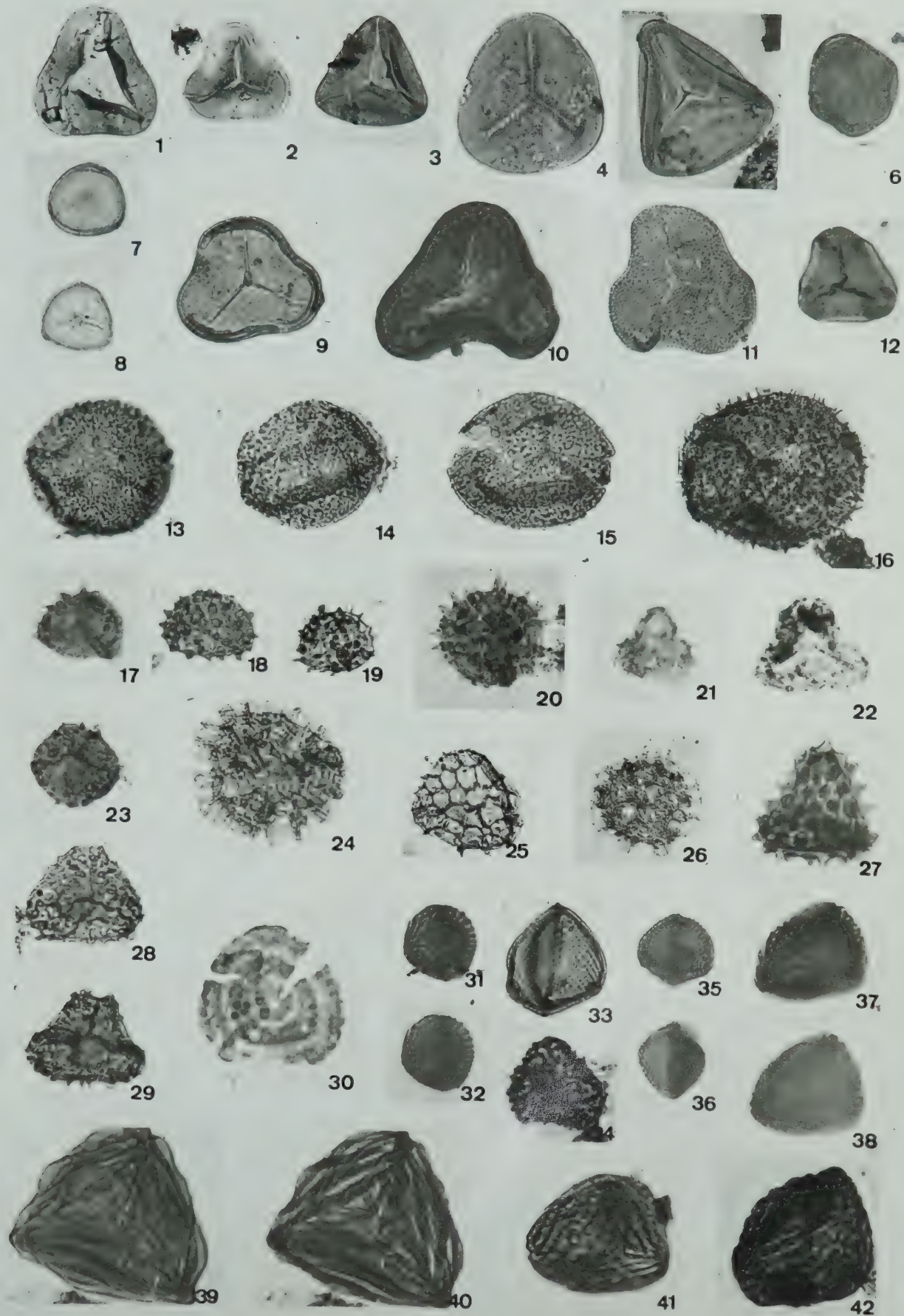


PLATE IX

(All figures are illustrated at a magnification of
x500 unless otherwise stated)

- | | | |
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PLATE IX.



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